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MONTANA STATE HIGHWAY DEPARTMENT

HIGHWAY PLANNING SURVEY

IN COOPERATION WITH

PUBLIC ROADS ADMINISTRATION

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ECONOMIC ANALYSIS AND RECOMMENDATIONS RELATIVE TO LOCATION OF FEDERAL-AID ROUTE NO. 49 BETWEEN TWIN BRIDGES AND DILLON

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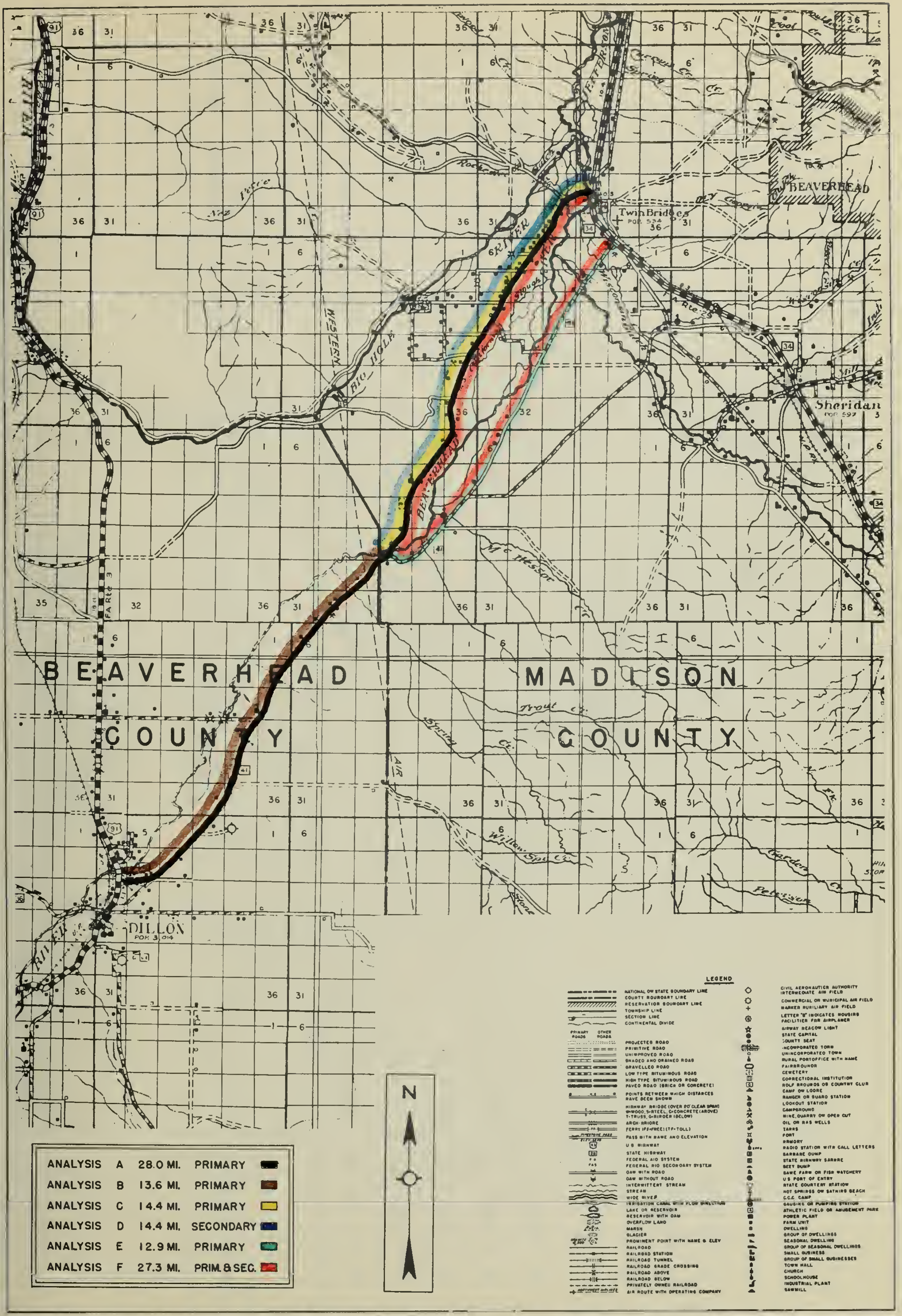
January 1946



ANALYSIS	A	28.0 MI.	PRIMARY	⬛
ANALYSIS	B	13.6 MI.	PRIMARY	🟫
ANALYSIS	C	14.4 MI.	PRIMARY	🟨
ANALYSIS	D	14.4 MI.	SECONDARY	🟦
ANALYSIS	E	12.9 MI.	PRIMARY	🟩
ANALYSIS	F	27.3 MI.	PRIM. & SEC.	🟥

Montana State Highway Department
Traffic and Planning Section
Public Roads Administration
Basic Design Categories
Table No. 1

					Sight Distance								
					Non Passing			Passing					
Standard	Average Daily Traffic	Classification	Max. Grade	Max. Curvature (Degree)	Horiz. Curvature (Degree)	Vertical Curvature (Algebraic Difference)	Feet	Feet	Shoulder Width	Width of Road Bed at Grade	Width of Surfacing	Minimum Type of Surfacing	Minimum Base Course
0	0-200	20 M 40	7	14	14	SEE TABLE NO. 2.	280	800	3	24	18	Under 1" Oil	5"
1	201-400	50 M 40	7	14	14		290	800	4	28	20	2" Oil	6"
2	401-800	100 M 40	7	14	14		310	1100	5	32	22	2½" Oil	8"
3	801-1800	200 M 40	7	14	14		320	1100	6	34	22	2½" Oil	8"
4	1801-3500	300 M 40	7	14	14		330	1100	8	38	22	2½" Oil	8"
5	0-200	20 M 60	6	6	6		460	1700	3	26	20	Under 1" Oil	5"
6	201-400	50 M 60	6	6	6		460	1700	4	30	22	2" Oil	6"
7	401-800	100 M 60	6	6	6		470	2100	5	32	22	2½" Oil	8"
8	801-1800	200 M 60	6	6	6		480	2100	6	34	22	2½" Oil	8"
9	1801-3500	300 M 60	6	6	6		500	2100	8	38	22	2½" Oil	8"

Note: Roads having over 3500 vehicles per day require special design.

TABLE NO. 2

Table giving length of vertical curve required for various Non - passing sight distances

December 18, 1943

Algebraic Difference between grades for convex curvature.	Length of vertical curve for a Non-passing sight distance of: 280 feet	Length of vertical curve for a Non-passing sight distance of: 290 feet	Length of vertical curve for a Non-passing sight distance of: 310 feet	Length of vertical curve for a Non-passing sight distance of: 320 feet	Length of vertical curve for a Non-passing sight distance of: 330 feet	Length of vertical curve for a Non-passing sight distance of: 460 feet	Length of vertical curve for a Non-passing sight distance of: 470 feet	Length of vertical curve for a Non-passing sight distance of: 480 feet	Length of vertical curve for a Non-passing sight distance of: 500 feet
1.00	96	103	117	125	133	258	269	281	305
2.00	191	205	234	250	266	516	539	562	610
3.00	287	308	352	375	398	774	808	843	915
4.00	382	410	469	500	531	1032	1078	1124	1220
5.00	478	513	586	624	664	1290	1347	1405	1524
6.00	574	615	703	749	797	1548	1616	1686	1829
7.00	669	718	820	874	930	1806	1886	1967	2134
8.00	765	820	938	999	1062	2064	2155	2248	2439
9.00	860	923	1055	1124	1195	2322	2425	2529	2744
10.00	956	1026	1172	1249	1328	2581	2694	2810	3049
11.00	1052	1128	1289	1374	1461	2839	2963	3091	3354
12.00	1147	1231	1406	1499	1594	3097	3233	3372	3659
13.00	1243	1333	1524	1623	1726	3355	3502	3653	3963
14.00	1339	1436	1641	1748	1859	3613	3771	3934	4268

MONTANA HIGHWAY PLANNING SURVEY

GUIDES FOR ESTIMATING 1960 TRAFFIC

			Applies to:
1.	100%	= 1941 traffic.	
2.	110% to 125%	= Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies to sparcely settled rural areas. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
3.	125% to 150%	= Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies in checkerboard well-settled rural areas or on through-roads. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
4.	150% to 200%	= Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. This applies in exceptional cases such as bottlenecks and natural cutoffs. Some cases, of course, might be much more but these special conditions would require special analysis.
Note:		Date of expected improvement does not change traffic estimates for 1960.	(Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).

130% = expected secular growth 1941 to 1960 --	to be applied to all above conditions except traffic generated by logging activities, or other major industries.
Applies to all roads now constructed. (Without any of above increases)	

Average summer maximum traffic equals double average ADT except on predominately recreational routes where factor might be as high as 3.

Average summer maximum traffic equals average of several maximum summer days.

Maximum hour equals 10% of maximum summer ADT. (Usual public traffic), or 15 to 20% on roads used by both the public and by major logging operations or other major industries.

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APPLICATION OF THE OREGON SOLVENCY QUOTIENT METHOD IN THE SELECTION OF HIGHWAY ROUTINGS BETWEEN THE POINT OF ROCKS AND TWIN BRIDGES IN MADISON COUNTY ON FEDERAL AID ROUTE NO. 49

I. SUMMARY OF FINDINGS

As a result of certain analyses brought out in detail in Section IV of this report we know that road construction in the area cited in the title hereabove is a feasible and profitable enterprise from the standpoint of highway finance. In fact, if we draw our conclusions on the basis of solvency quotients alone, we would say that there is ample justification for building the primary routing from the Point of Rocks to a point two miles south from Twin Bridges on Federal-aid Route No. 49 as it is presently designated and constructing a road to secondary standards from the Point of Rocks to Twin Bridges on the west side of the Beaverhead River. However, there are several factors which are not readily apparent when one quotes a solvency quotient as evidence of the feasibility of highway construction in any given area - these factors are particularly important in this problem. For example, it is estimated that 138 vehicles per day will be diverted to the Dillon, Twin Bridges, Whitehall, Boulder routing when it is built throughout its length. This traffic is present in such number and weight as to render the selection of the routing from the Point of Rocks to Twin Bridges a problem of state-wide interest. It is this possible increment of traffic which makes secondary highway construction west of the river and primary east of the river together a profitable action and by the same token the diverted traffic would be benefited almost equally, were a single primary routing built either west or east of the river. Having established parity in benefits insofar as the diverted traffic is concerned, we turn next to the service possibilities of a combination routing east and west of the river. Here we find, as will be brought out in the latter phases of this report, that local traffic on the west leg will be 222 vehicles per day as opposed to a total of 66 vehicles per day, on the leg east of the river. In other words, the road west of the river will serve 77% of the local residents in termsof traffic volume while the routing east of the river will serve but 23%.

Another way to look at the problem is on the basis of efficiency in the expenditures of highway funds. Let us weigh expenditures against benefits in terms of dollars and cents. To do so, let us accept the idea that it is feasible to build both east of the river and west of the river from the Point of Rocks to Twin Bridges and that the benefits which will thus accrue to traffic, local and diverted, in relation to expenditures, represent a condition somewhat less than ideal and thus subject to modification as best suits the local residents. These data are platted on the chart, page 3 of this section - the solid line, ratio 1.44, shows that benefits are 44% in excess of estimated expenditures. Next, let us plat expenditures and benefits resulting from construction of 14.4 miles of primary highway west of the river and find the ratio, benefits to expenditures, to be 2.14, once and a half times that in evidence when roads are built both east and west of the river. Furthermore,

the anticipated expenditures will be but $27,575, 61.6% of that anticipated in the first instance, while the benefits will be $59,084, 91.6% of the benefit values for the combined routings. For the taxpayers' dollar the best choice is certainly primary construction west of the Beaverhead River.

Such a solution does not, admittedly, satisfy the wants of those Madison County people who are resident immediately east and south of the Beaverhead River and in the Sheridan-Virginia City region. It is a fitting economic solution of the problem for the people of Madison County as a whole, however, and it will enable the county officials to request a switch of funds originally "ear marked" for secondary construction west of the Beaverhead River between Twin Bridges and the Point of Rocks to other districts wherever the ratio, benefits to expenditures would exceed that shown as a remainder on the Ratio Chart.

II. ROUTE DESCRIPTIONS

The routes and combinations of routes proposed for analysis are as follows:

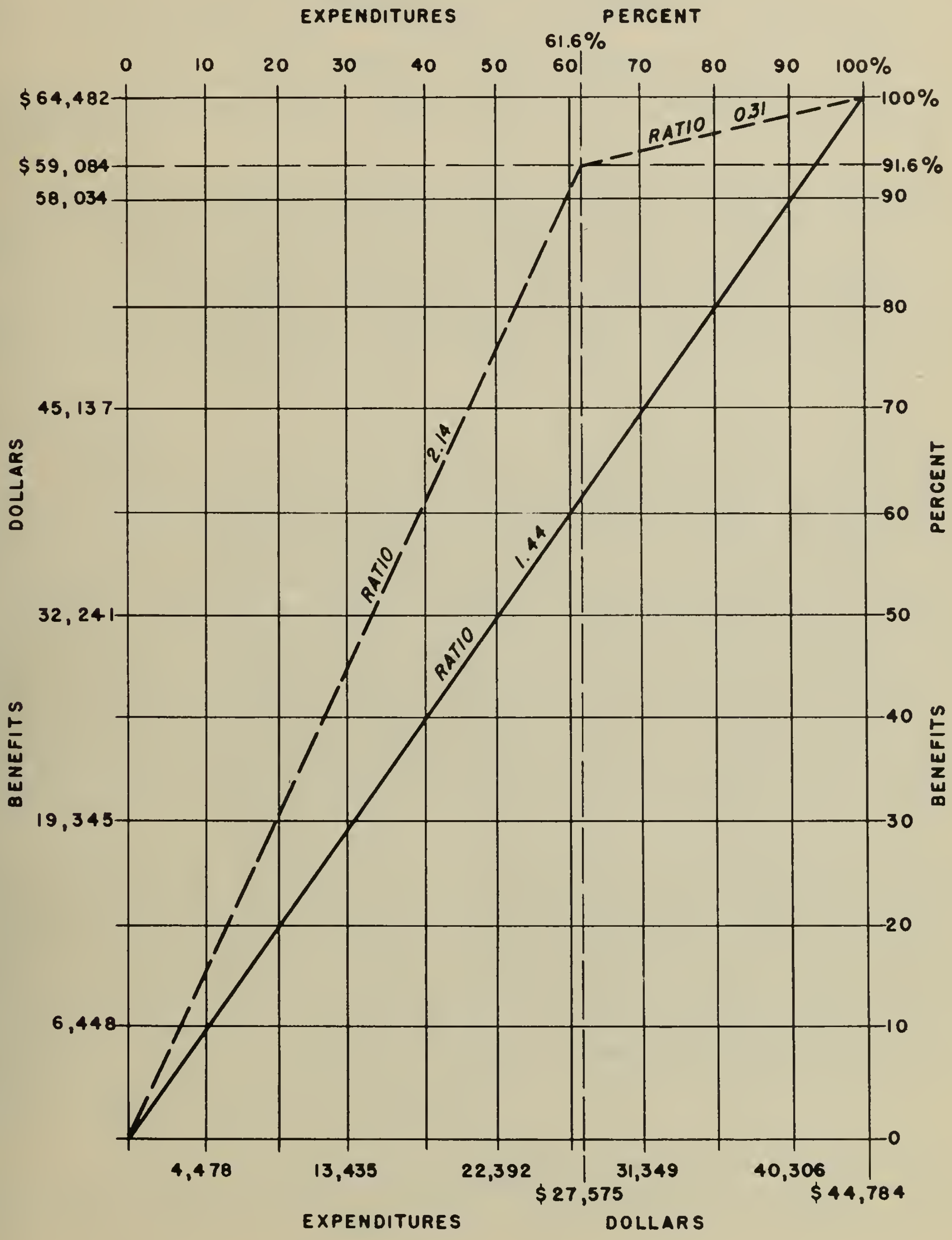
A. DILLON TO TWIN BRIDGES, Primary in Beaverhead and Madison Counties, 28.0 miles. In Beaverhead County the road follows the designated location of F.A. Route No. 49 from its origin on F.A. Route No. 3 on the northeasterly outskirts of Dillon to the Beaverhead County line near the Point of Rocks in Madison County, a distance of 13.75 miles. At the Point of Rocks the routing drosses the Beaverhead River, thence northeasterly via the present travelled way to the outskirts of Twin Bridges, where it again crosses the Beaverhead River to make a junction with F.A. Route No. 29 in that town. Total distance in Madison County - 14.75 miles - to make the distance from Dillon to Twin Bridges via the present travelled way 28.5 miles. On completion of construction it is anticipated that the route distance will be 28 miles, 14.65 miles in Madison County and 13.35 miles in Beaverhead County, to effect a saving of 0.1 miles and 0.4 miles respectively, in each county.

From the junction near Dillon toward the Point of Rocks for a distance of 6.5 miles the road was graded and gravelled with Federal-aid in 1936 and 1940 - this interval is programmed for re-shouldering, re-gravelling, and oil surfacing to bring it up to current acceptable standards for primary Federal-aid Routings. From the end of this section to the Point of Rocks and thence to Twin Bridges via the west side of the river, the road must be graded, drained, gravelled, and oil surfaced - two bridges must be built; one near the Point of Rocks and one at Twin Bridges. The portion of the road in Beaverhead County will be comparatively easy to build with the exception of a short interval near the Point of Rocks where irrigation and drainage facilities will pose some little difficulty. That section north and west of the river will traverse a lowland area, with a high water-table along with numerous irrigation facilities to render a cost some $2,000 per mile in excess of that estimated for a primary routing east of the Beaverhead River. The costs are exclusive of costs estimated for major drainage structures cited hereinbefore. In keeping with the Basic Design Categories, see pages i, ii, the route as proposed for analysis will be built to Standard No. 6.

RATIO CHART

BENEFITS TO EXPENDITURES

POINT OF ROCKS - TWIN BRIDGES



B. Dillon to the Point of Rocks, Primary 13.35 miles in Beaverhead County and 0.25 miles in Madison County. See description and discussion in paragraph A, this section.

C. Point of Rocks to Twin Bridges, Primary 14.4 miles in Madison County. See description and discussion in paragraph A, this section.

D. Point of Rocks to Twin Bridges, built to Secondary standards, 14.4 miles in Madison County. See description and discussion in paragraph A, this section.

E. Point of Rocks to Twin Bridges, Primary, 12.9 miles, on east side of Beaverhead River as per designation F.A. Route No. 49. This location traverses a sparsely settled area as compared to the routing west of the river. The terrain is flat, there are fewer irrigation facilities to cope with, and but one major stream crossing to build. All these advantages combine to render a cheaper construction cost than that estimated for the routing west of the river. See paragraph A, this section, for design features.

III. TRAFFIC

Traffic and vocational pursuits are inter-related to a remarkable degree - given an economy which has suffered by virtue of "hard times" one will find a significant decrease in traffic volumes. Given prosperous times, one will find a significant increase in traffic. It is not claimed that there is a true dollar-for-dollar relationship in the two variables, economy and traffic. However, the relationship is binding enough for us to say that traffic records are indicative of economic trends and that fluctuations in such records are indicative of similar rise and fall in the economic pattern of the area being studied. By so treating with the economy of the area along a given routing, we thus avoid manipulation of ponderous business and production statistics; our traffic records will suffice. It remains for us, however, to label the existing traffic and that which might develop in the future in terms of the economic function which prompts, or might prompt, such traffic.

Here, as in other rural areas of Montana, the economy is based chiefly on farming. There are some few quartz and placer mining operations in Madison County but the effect of this industry is not unduly significant insofar as the routes under consideration are concerned. Stock raising, both cattle and sheep, provides the principal cash income, both in the area which the routes traverse and in those areas contiguous thereto. Twin Bridges, Sheridan to a lesser degree, and Dillon are so strategically located as regards shipping and feeding facilities, that it is necessary in the solution of this particular problem to classify the traffic through these towns. Accordingly, we have categories as follows:-

A. "Dillon - Beaverhead", being that element of local traffic which has origin or destination in the immediate vicinity of F.A. Route No. 49 in Beaverhead County.

B. "Dillon-Twin Bridges", being that element of traffic which would pass through or originate in and proceed to both towns as listed. In this connection, it has been estimated that 20% of such traffic would have origin in, near, or south of Sheridan and 80% would have origin or destination in,

or near Twin Bridges. In this particular instance, it is presumed that the Dillon-Sheridan traffic would prefer the roundabout trip via Twin Bridges as compared to the rural road leading easterly from the Point of Rocks.

C. "Dillon-Sheridan, Partial", being that element of traffic which would use the F.A. Routing from Dillon to the Point of Rocks, a distance of 13.6 miles, thence easterly and southeasterly to Sheridan.

D. "Point of Rocks-Twin Bridges", being that element of local traffic which builds up between the Point of Rocks and Twin Bridges on either the west side of the river or the east side of the river.

E. "Point of Rocks-Sheridan", being that element of traffic which builds up between the Point of Rocks and Sheridan.

F. "Diverted Traffic", being that element of traffic which might be diverted to the routing or routings from US-91.

These several elements of traffic are platted on the Traffic Profile Charts set forth on the next following pages of this report.

The first chart illustrates the segragation of traffic, as of 1960, were the routing to extend from Dillon to the Point of Rocks thence to Twin Bridges on the west side of the Beaverhead River. Attention is directed to the significant volume of Point of Rocks-Twin Bridges traffic. The second chart shows the classification and volume of traffic, should the route extend from Dillon to the Point of Rocks to a junction with F.A. Route No. 29 near Twin Bridges. Note the effect of the loss of the "west side" Point of Rocks-Twin Bridges traffic. The third chart illustrates the condition which might conceivably obtain, should the primary be built east of the river as presently designated and the secondary west of the river. Under these conditions of construction it is assumed that the bulk of the diverted traffic would follow the primary routing despite the fact that the west side route would be one-half mile shorter. Here again the "west side" Point of Rocks-Twin Bridges traffic exerts a tremendous "pull" to that route.

The analyses which follow (see Section IV) are predicated on possibilities which might obtain in 1960 - but we do not know of, nor do we attempt herein to forecast, the 1960 economy of Madison and Beaverhead Counties and the areas contiguous thereto. However, we have recourse in traffic trends and patterns, which, as we have stated hereinbefore, are almost synonymous and equally effective with economic trends. The patterns and bases of traffic estimation, in other words, are liberal and comprehensive enough, we believe, to provide for any fundamental or basic change of the economy in any given area.

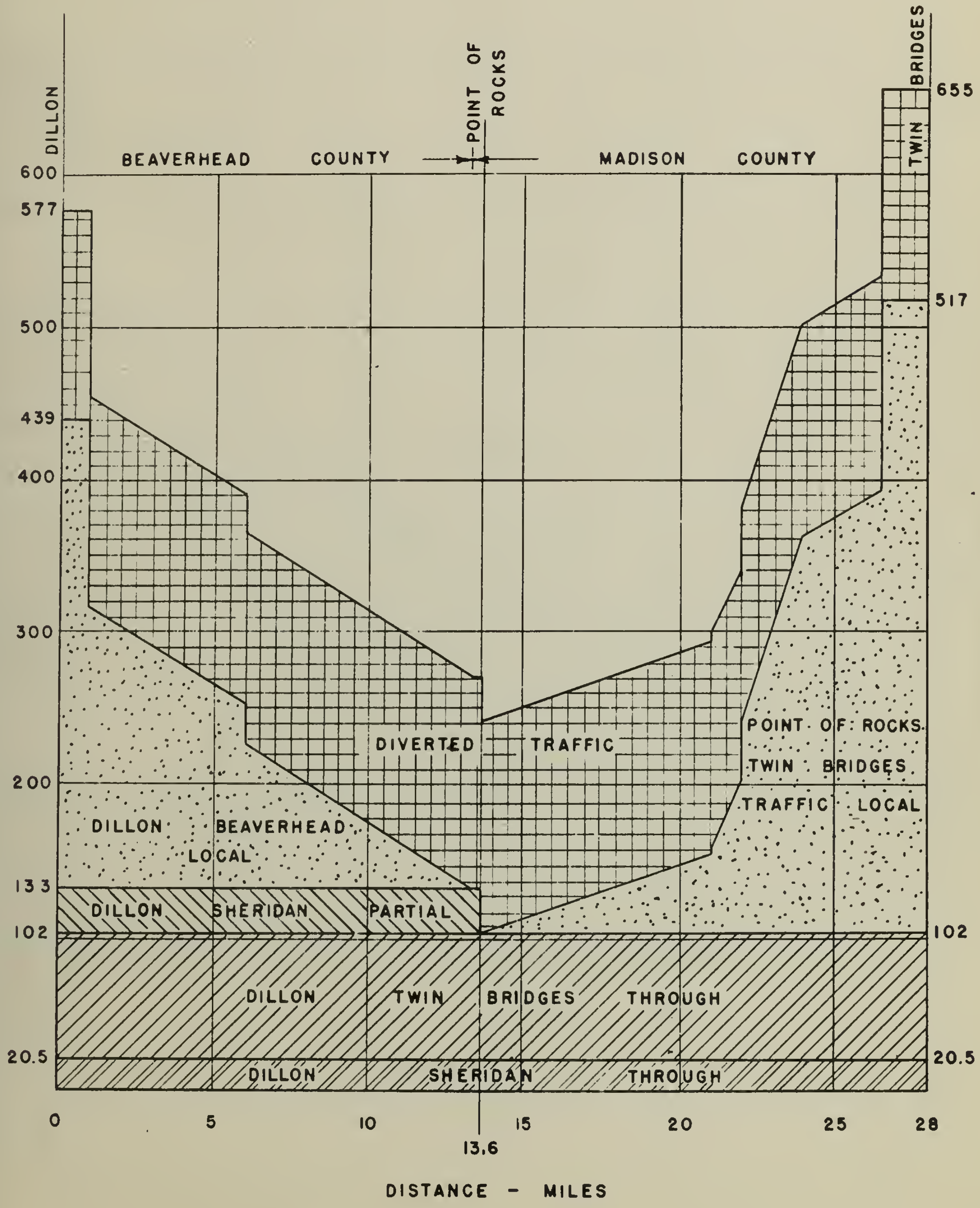
Aside from local aspects of the problem we have the possibility of diversion to the route or routes should they be built. For example, if any of the several routes proposed for analyses were built, it would form a link in a route extending from Dillon through Whitehall to Boulder over an easy grade; furthermore, that diverted traffic having origin or destination on US-10 east of Whitehall would save 40 miles and that diverted traffic having

I

TRAFFIC PROFILE 1960

DILLON - TWIN BRIDGES, 28 MI.

PRIMARY WEST OF BEAVERHEAD RIVER

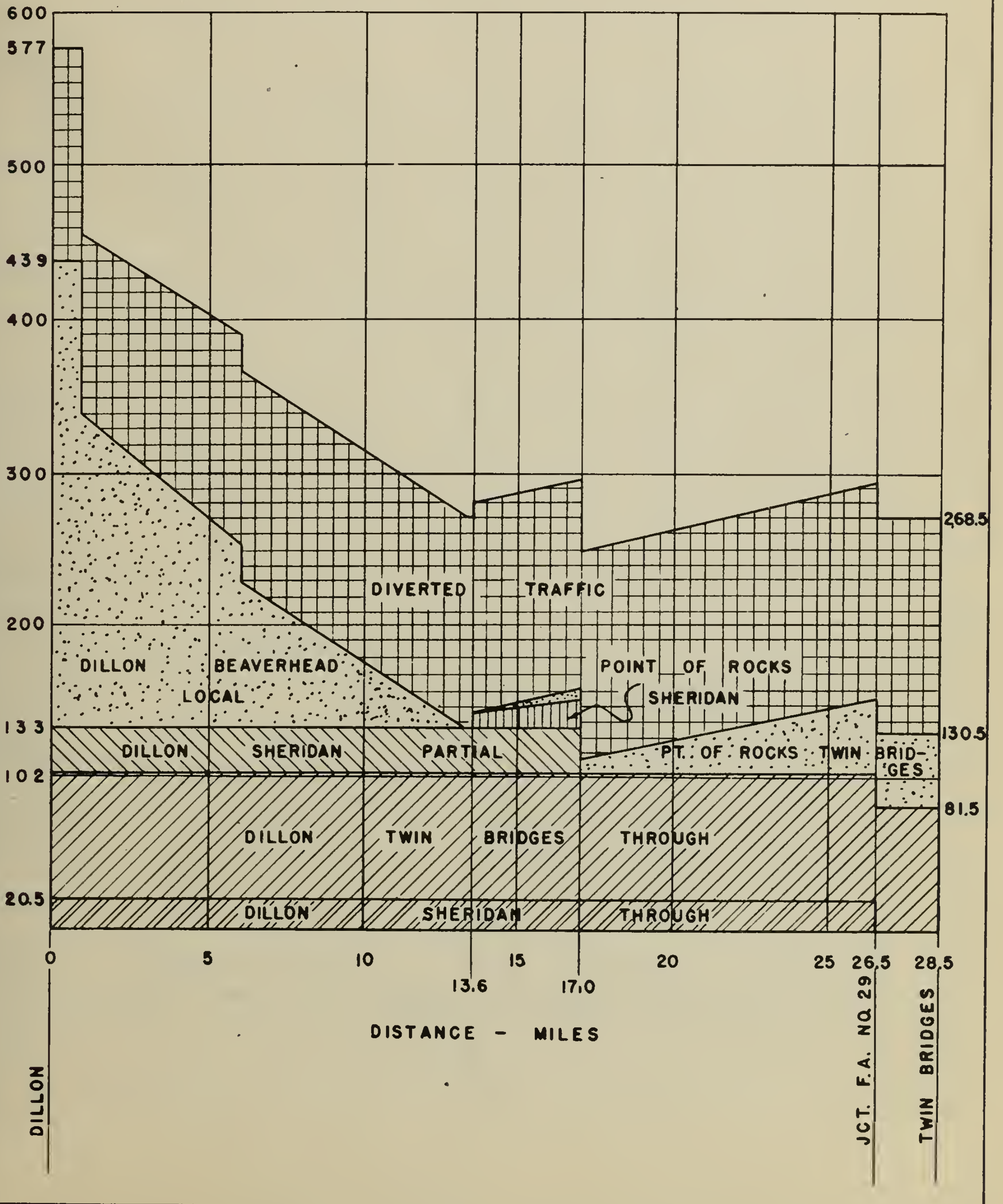


II

TRAFFIC PROFILE

DILLON - TWIN BRIDGES, 28.5 MI.

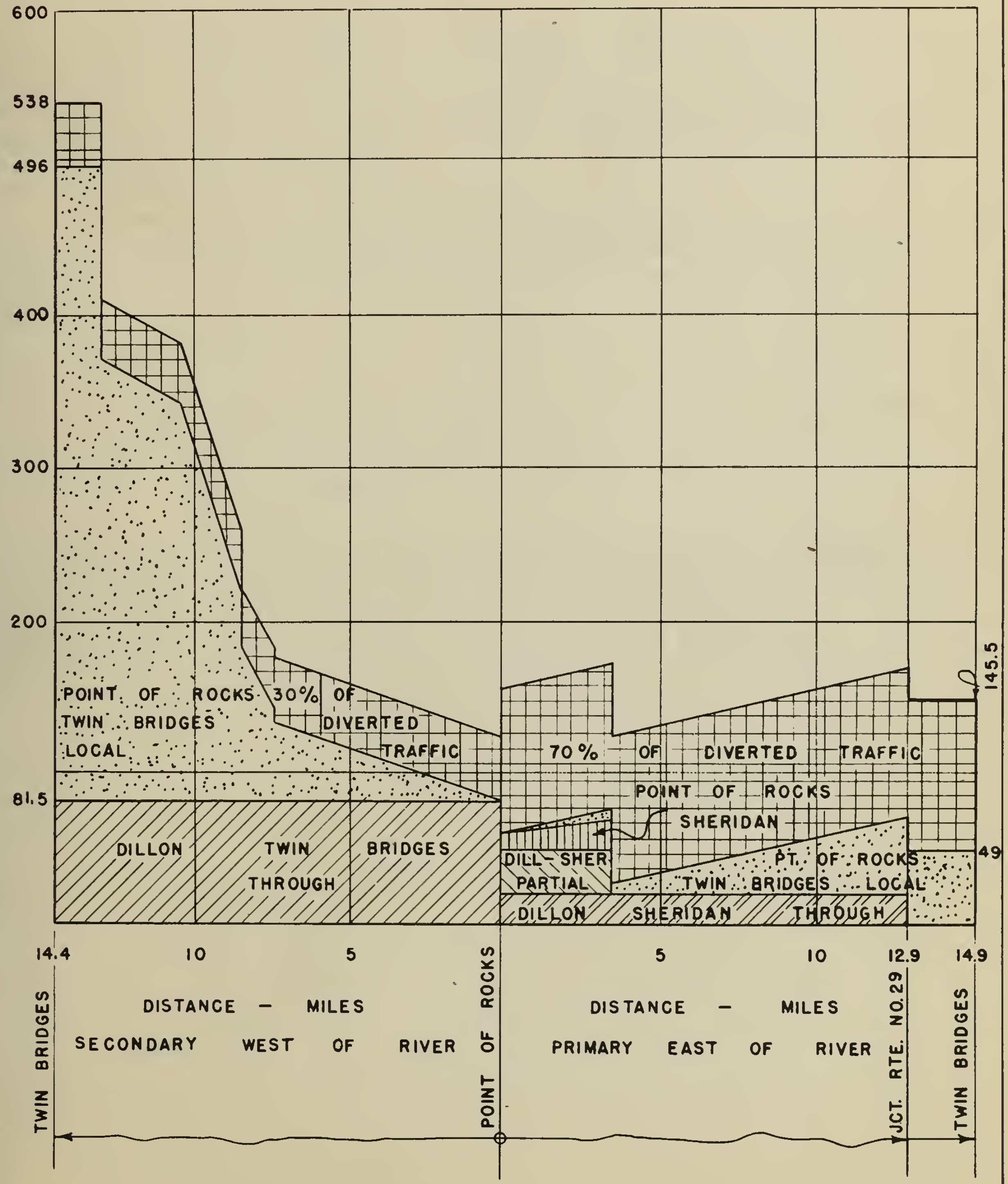
PRIMARY EAST OF BEAVERHEAD RIVER



III

COMPARATIVE TRAFFIC PROFILE CHART

COMBINED ROUTES 12.9 MI. PRIMARY EAST OF RIVER & 14.4 MI. SECONDARY WEST OF RIVER



origin or destination north of Boulder would save 17 miles. In both cases, traffic would avoid congestion on the streets of Butte. On the other hand, Butte is an established community, it is a marketing center for a considerable area, it is also a place of interest to tourists and casual Montana travelers; will economic aspects so change in the future that commercial and industrial traffic will have less occasion to "call" in Butte?

The foregoing discussion is an extreme possibility; the real question is: How much commercial traffic, heavy hauling, as it were, having no interest in Butte, will take advantage of the water grade route from Dillon to Whitehall and Boulder, or vice versa? As for tourists and pleasure drivers, how many of such category would choose to miss Butte to take advantage of a less scenic route to save distance and time?

This discussion presents the possibilities inherent in the improvement of any of the routings under study. The data are now assembled to draw out specific conclusions in reference to the choice of the route or routes to be improved.

IV. ECONOMIC ANALYSES

A. DILLON-TWIN BRIDGES, Primary, via Point of Rocks and the West Side of the River, 28 miles.

1. Annual Cost Calculations.

It is assumed that the routing will be built to Standard No. 6 (See Basic Design Categories, pages i, ii), this in keeping with estimated traffic volumes as developed in sub-section 2 of this section. Costs would approximate those experienced in the construction of WPSO 344A-B near Dillon and FAP 281C north of Twin Bridges and FAP 281F south of Sheridan. Both of the latter mentioned projects were constructed as part of F.A. Route No. 29, the Vigilante Trail. Cost data are presented herewith:

BASIC CONSTRUCTION COSTS

Const. Year	Length	Project No.	Grading	Drainage		Gravel Base & Surfac.	Oil Surfacing	R/W	Engineering	Administration
				Minor Structures	Major Structures					
1937	6.7	281C	$ 74738	$ 9811		$ 16338		14740	10024	1213
1939	6.7					$ 13110	$ 14645		2530	
1939	11.3	281D	$ 27935	$44658		$ 52329	$ 30202		17901	
1940	7.1	281F	$ 34722	$29257		$ 39034	$ 13626		10583	
1938	0.005	281D			$ 1609				434	
1940	0.014	281F			$ 5237				475	
Totals	25.1		$137395	$83726	$ 6846	$120811	$ 58473		41947	1213
Averages	25.1	281C,DF	5474	3336		4813	2330		1635	
Averages	6.7	281C	11155	1464		4395	2186	2200	1874	181
Averages	18.4	281D, F	3405	4017		4965	2382		1548	
Averages	11.3	281D	2472	3952		4631	2673		1584	
Averages	7.1	281F	4890	4121		5498	1919		1491	
Averages	13.8	281C,F	7932	2831		4962	2049		1677	88
1936	2.6	344A	22718	4564		13512		2456	3465	724
1940	3.9	344B	18575	12658		1248			4944	
Totals	6.5		41293	17222		14760		2456	8409	724
Averages	6.5		6353	2650		2271		378	1294	111
Averages	2.6		8748	1755		5197		945	1333	467
Averages	3.9		4763	3246		320			1268	

Drawing on this experience and making due allowance for possible increase in unit prices in the post-war period, we find reasonable costs per mile as follows:-

Dillon through Projects WPSO 344A, B, - 6.5 miles

Grading.................................... $ 500

Assuming that there will be re-shouldering operations preparatory to gravel surfacing.

Gravel Base and Surfacing...................... $ 2,000

These projects having been gravel surfaced in 1936 and 1940, it is assumed that this item will comprise a restoration process at a cost similar to that experienced in the original construction.

Oil Surfacing.................................. $ 2,300

At a cost similar to, but somewhat in excess of that experienced in the oil surfacing of FAP 281C.

Engineering.................................. $ 700

Sub-Total.... $ 5,500

+ 10% for contingencies..... 550

Total estimated cost per mile... $ 6,050

From the end of WPSO projects 344A-B to the Point of Rocks, 7.1 miles.

Grading...................................... $ 3,400

Assuming costs similar to those experiences in the construction of FAP 281 C,D. It is to be noted that costs in evidence on WPSO 344A,B were unbalanced by certain hour-labor controls in effect in the 1936-1940 program.

Minor Drainage Structures.................... $ 2,700

Assuming costs somewhat in excess of those experienced in 1936-1940 on the construction of WPSO 344A-B.

Major Drainage Structures.................... $ 500

Assuming it might be necessary to install a few pile structures.

Gravel Base and Surfacing.................... $ 4,500

Assuming costs similar to those experienced in the construction of FAP 281C north of Twin Bridges.

Oil Surfacing................................ $ 2,300

Assuming costs similar to those experienced in the construction of FAP 281C, D, F on the Vigilante Trail.

Right of Way................................. $ 1,000

Assuming costs similar to those experienced in the construction of WPSO 344A near Dillon.

Engineering.................................. $ 1,700

Assuming costs similar to those experienced in the construction of FAP 281C, D, F on the Vigilante Trail.

Sub-Total........ $ 16,100

+ 10% for contingencies........ $ 1,610

Total estimated cost per mile........ $ 17,710

From the Point of Rocks northerly to Twin Bridges via the west side of the river, 14.4 miles.

Grading.. $ 5,000

Assuming costs similar to those experienced in the construction of FAP 281C and FAP 281F which projects traversed similar terrain.

Minor Drainage Structures.............................. $ 3,000

Assuming costs similar to those experienced in the construction of FAP 281C,F.

Gravel Base and Surfacing.............................. $ 4,500

Assuming costs similar to those experienced in the construction of FAP 281C and F.

Oil Surfacing.. $ 2,400

Assuming costs similar to those experienced in the construction of FAP 281C,D,F, Iron Rod through Sheridan to Alder on the Vigilante Trail, FA Route No. 29.

Right of Way.. $ 1,500

Assuming increased costs because of concentration of farm holdings in the area which this section traverses.

Engineering.. $ 1,700

Assuming costs similar to those experienced in the construction of FAP 281C, D, F.

Administration... $ 100

Assuming costs similar to those experienced in the construction of FAP 281C, D, F.

Sub-Total........ $ 18,200

+ 10% for contingencies........ $ 1,820

Total estimated cost per mile, grading, drainage, gravel base and gravel surface and oil surfacing..... $ 20,020

Major Structures........ $120,000

Two bridges, one at the Point of Rocks and one at Twin Bridges.

The total new construction cost exclusive of the two bridges would then be:

$$\begin{aligned} 6.5 \times \$\ 6{,}050 &= \$\ 39{,}325 \\ 7.1 \times \$17{,}710 &= \$125{,}741 \\ 14.4 \times \$20{,}020 &= \underline{\$288{,}288} \\ &\ \$453{,}354 \end{aligned}$$

Add to this the cost of the bridges to bring the total to $573,354.

The total outlay for the construction of WPSO 344A,B in 1936-1940 was $84,864, hence the total cost on a capitalization basis will be $658,218 ($573,354 + $84,864).

It is believed that traffic will demand or require roads of higher standard as time goes on, to thus require a greater outlay on reconstruction. Interest charges should be assigned in recognition of this feature - in other words, the road "as built" should lay up a reserve to meet increased construction costs in the future. Accordingly, the construction costs, exclusive of the major structure costs, have been assigned an interest charge of 2½% to be amortized in twenty years. The major structure costs were assigned an interest charge of 2½% to be amortized in forty years. The time period in each instance is deemed significant of the service life of the proposed improvement.

Assigning interest charges as set forth hereinabove, we have an annual capital cost of:

$$\begin{aligned} 0.0641\ (\$453{,}354 + \$84{,}864) &= \$34{,}500 \\ 0.0398\ (\$120{,}000) &= \underline{4{,}776} \\ &\ \$39{,}276 \end{aligned}$$

From data at hand and in due consideration of the traffic load and the adverse drainage conditions inherent in the proposed construction, it is estimated that maintenance costs will approximate $300 per mile to render an annual maintenance cost of $8,400 over the length of the proposed routing. The total annual capital cost would then be $47,676: ($39,276 + $8,400).

These data are set forth in somewhat lesser detail in the tabulation of ANNUAL COST CALCULATIONS which follows hereinafter.

ANNUAL COST CALCULATIONS

Location of project Montana County Beaverhead - Madison
Description of project Dillon - Twin Bridges
Highway number FA Route No. 49 Highway system FA Primary
Length 28.0 miles Date of analysis December 1945

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	$ 31,156	2½%	20 yrs.	$ 1,997
Clearing, grading, etc.	140,683	2½%	20 yrs.	9,018
Pavements and surfacing:	190,350	2½%	20 yrs.	12,201

CAPITAL COSTS (Cont)

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Structures:				
Type Minor	$ 79,592	2½%	20 yrs.	$ 5,102
Type Major	123,550	2½%	40 yrs.	5,004 1/
2/Other Construction items:....	92,887	2½%	20 yrs.	5,954
Unamortized cost const.......	658,218	2½%		
1. Total annual capital cost construction..................				$ 39,276

MAINTENANCE COSTS

	Gross Cost 3/
2. Annual maintenance cost 28 miles at $300	$ 8,400
TOTAL ANNUAL COSTS (1 + 2)	$ 47,676

1/ $120,000 at 2½% for 40 yrs.
3,550 at 2½% for 20 yrs.

2/ Engineering administration and 10% for contingencies included with "Other Construction Items"

3/ To include administration and overhead.

2. Average Daily Traffic, 1960

As brought out in Section III of this report there are several elements of traffic comprising the whole of traffic for each route proposed for analysis, all of which can be classified under the general headings of "Existing traffic" and "Diverted traffic".

a. Existing traffic.

We have traffic records as of 1941 to indicate density between Dillon and Twin Bridges, origin-destination studies conducted at Dillon and Twin Bridges in 1936 give us a clue as to general travel intent for the traffic under survey. By use of the guide for estimating traffic (see page iii) we may arrive at a reasonable estimate for traffic as it will obtain in 1960.

It is generally conceded that as transport develops, now and in the future, the swing will be toward the highway medium and this trend or tendency will have a marked effect on traffic, particularly the ratio of trucks to passenger cars as of 1960. Accordingly, if we were to apply the ratios, trucks to passenger cars as they existed in 1936 and 1941 at Dillon and Twin Bridges, we would be ignoring the possibility of any great change in traffic characteristic in the years to come. Furthermore, it can well be said that the traffic "sample" at Dillon and Twin Bridges is comparatively light when we survey traffic as a whole in the State of Montana and any estimate or prediction of future trends which would be based on such data would be somewhat lacking in complete qualification insofar as "sample" backing is concerned. In short, we believe that the ratio of trucks or

commercial vehicles to passenger cars in the future will be far in excess of that manifested on the highways, primary and secondary, in 1936 and 1941 and that traffic classification records pertaining to the Dillon-Twin Bridges area which we have at hand are not so comprehensive as to allow us to forecast traffic characteristics in 1960. So we turn to records which give us a more complete picture of traffic characteristics on a well used primary highway and a correspondingly well used secondary highway. In the first instance we have recourse to the automatic counter records at Wolf Creek on US-91 between Helena and Great Falls and in the second instance we have the records and classification of secondary traffic at the Manhattan automatic counter station. In both cases, the records show a larger percentage of truck traffic than do the comparable stations at Dillon and Twin Bridges, and in addition to this feature there is a more general distribution of truck traffic by type, i.e., light, medium, heavy trucks, tractor-truck semi trailer combinations, truck and trailer combinations and busses. These data, it is believed, furnish a clearer insight to traffic and its components as of 1960 and the truck-passenger car relationships in this report are so based. The traffic estimates for 1960 are as follows:

DILLON-TWIN BRIDGES 28 Miles
EXISTING TRAFFIC, 1960

Category and Type 1/	Length Miles	1941	On Completion 50% of route 2/ + 25%	On Completion of through route 3/ + 50%	Normal Growth + 30% 1960
DILLON-BEAVERHEAD	13.35				
Passenger Cars, Local		50	62		81
Passenger Cars, Foreign		3	4		5
All Passenger Cars		53	66		86
Trucks, Light		9.5	11.8		14.5
Trucks, Medium		0.6	0.8		1.0
Trucks, Heavy		0.3	0.4		0.5
Trac. Tks. & Semi-Trlrs.		0.6	0.7		1.0
Trucks & Full Trailers		0.4	0.5		1.0
Busses		0.6	0.8		1.0
All Trucks and Busses		12.0	15.0		19.0
All Vehicles		65.0	81.0		105.0
DILLON-TWIN BRIDGES	28.0				
Passenger cars, Local		37		55	71
Passenger cars, Foreign		2		3	4
All Passenger Cars		39		58	75
Trucks, Light		11.0		16.5	21.2
Trucks, Medium		0.7		1.1	1.4
Trucks, Heavy		0.4		0.6	0.8
Trac. Tks. & Semi-Trlrs.		0.7		1.0	1.3
Trucks & Full Trailers		0.5		0.7	0.9
Busses		0.7		1.1	1.4
All Trucks and Busses		14.0		21.0	27.0
All Vehicles		53.0		79.0	102.0

DILLON-TWIN BRIDGES 28 Miles
EXISTING TRAFFIC, 1960 (Cont.)

Category and Type 1/	Length Miles	1941	On Completion 50% of route 2/ + 25%	On Completion of through route 3/ + 50%	Normal Growth + 30% 1960
DILLON-SHERIDAN, PARTIAL	13.6				
Passenger Cars, Local		13	16.2		22
Passenger Cars, Foreign		1	1.3		1
All Passenger Cars		14	17.5		23
Trucks, Light		4	5.0		6.0
Trucks, Medium		0.3	0.4		0.6
Trucks, Heavy		0.1	0.1		0.2
Trac. Tks. & Semi-Trlrs.		0.2	0.3		0.4
Trucks & Full Trailers		0.2	0.2		0.4
Busses		0.2	0.3		0.4
All Trucks and Busses		5.0	6.3		8.0
All Vehicles		19.0	23.8		31.0
POINT OF ROCKS-TWIN BRIDGES	14.4				
Passenger Cars, Local		51		77	99
Passenger Cars, Foreign		2		3	4
All Passenger Cars		53		80	103
Trucks, Light		15.2		22.3	29
Trucks, Medium		0.9		1.4	2
Trucks, Heavy		0.5		0.7	1
Trac. Tks. & Semi-Trlrs.		0.9		1.3	2
Trucks & Full Trailers		0.6		0.9	1
Busses		0.9		1.4	2
All Trucks and Busses		19.0		28.0	37
All Vehicles		72.0		108.0	140
ALL EXISTING TRAFFIC					
Passenger Cars, Local					170
Passenger Cars, Foreign					10
All Passenger Cars					180
Trucks, Light					45.9
Trucks, Medium					3.3
Trucks, Heavy					1.6
Trac. Tks. & Semi-Trlrs.					3.0
Trucks & Full Trailers					2.1
Busses					3.1
All Trucks & Busses					59.0
All Vehicles					239.0

1/ The method of allocating traffic to the several categories listed will be explained in the discussion of diverted traffic.

2/ See "Guide to Traffic Estimation" page iii. The Dillon-Beaverhead traffic is now served by 6.5 miles of completed highway; graded, drained, and gravel surfaced. The same principle applies to that portion of DILLON-SHERIDAN traffic as listed.

3/ See "Guide to Traffic Estimation".

b. Diverted traffic.

This section will treat principally with methods and procedures used in the calculation of traffic which might conceivably be diverted to this project when a through road is built from Dillon to Boulder via Twin Bridges and Whitehall. There are available and at hand in this office certain data resulting from the 1936-1937 Origin-Destination studies conducted at Dillon and Twin Bridges. During the course of these studies, cards were handed to passenger car drivers requesting information in reference to the origin and destination of the trip on which each driver was then engaged, and the state of registration. These cards were then to be forwarded to the Helena office of the Montana Highway Department for tabulation and study. As it happened, 14% of the Montana drivers and 25% of the out-of-state drivers returned cards from the Dillon station to afford a tenable basis in the calculation of the possible diversion and in the segregation of traffic categories as shown herebefore. On the basis of these data, it was determined that passenger car traffic would be diverted to the Dillon-Twin Bridges road when built as shown by the tabulation which follows this discussion.

ORIGIN DESTINATION STUDY; 1936-1937
DILLON STUDY POINT

ORIGIN	NO.	POSSIBLE DIVERSION	OUTLOOK	SHERIDAN	TWIN BRIDGES	VIRGINIA CITY	WHITEHALL	DILLON	GLENDIVE	MILES CITY	BOZEMAN	HELENA	MISSOULA	GREAT FALLS	BUTTE	BEAVERHEAD	MADISON	SILVER BOW	ARIZONA	BRIT. COLUMBIA	CALIFORNIA	IDAHO	MINN.	SOUTH DAKOTA	WASHINGTON	WYOMING	REMARKS
Outlook	9	4.5																			9						Divert one-half trips
Sheridan	18							9														9					
Terry	8	4.0																			8						Divert one-half trips
Twin Bridges	9							9																			
Wibaux	9	4.5													9												Divert one-half trips
Dillon	265	4.0			36		9				8				72	104	18	9				9					Divert ½ trips to Bozeman
Bozeman	18	4.5						9							9												Divert ½ trips to Dillon
Livingston	16	8.0																				8			8		Divert one-half trips
Billings	10	5.0						10																			Divert one-half trips
Helena	19	9.5						10					9														Divert one-half trips
Butte	29							29																			
Beaverhead	148	5.0						75						10	18	37	8										Divert ½ trips to Gt. Falls
Madison	26					9		8															9				
Lewis & Clark	8	4.0																	8								Divert one-half trips
ADT., Local 1936-37	592	53.0			36	9	9	159			8		9	10	108	141	26	9	8		17	26	9		8		
California	28	3.3	4					9							3					3		3				6	Divert 1/3 to Outlook & Wyo.
Colorado	9	1.7											4													5	Divert 1/3 to Wyoming
Idaho	13	3.3										4			3									6			Divert 1/3 to Helena & So.Dak.
Nebraska	3			3																							
Oregon	3														3												
Washington	30	7.0						6	6	9				6	3												Divert 1/3 Glendive, Miles City & Great Falls
ADT., Foreign 1936-37	86	15.3	4	3				15	6	9		4	4	6	12					3		3		6		11	

The ORIGIN-DESTINATION SUMMARY should not be interpreted to mean that there will be a certain stipulated amount of traffic originating in Outlook, for example, destined for California. Rather, it should be read with the idea in mind that some few trips in the number or percentage of the example with origin in the state and far removed from the study point will pass through Dillon on the way to a destination outside the state. As a conservative approach to the allocation of possible diversions the writer has estimated that a traveller would still go through Butte about one-half of the time, even though there were a cut-off afforded him at Boulder. In the case of "foreign" drivers the writer estimated that they would avail themselves of the cut-off about 1/3 of the time, due consideration being thus given to tourist attractions in Butte and the mountainous areas surrounding that city.

There being no available data in re possible truck diversions, the writer reasoned that such traffic would follow the diverted passenger cars in the same proportions in evidence at Wolf Creek. (See discussion, Page 15 of this report).

There are two categories of diverted traffic involved in these analyses; that portion which will divert at Dillon and proceed through to Boulder and the balance of diverted traffic, which will go through to Whitehall and turn east on US-10. It is necessary to so classify the diverted traffic in order that we may allocate benefits in the latter phases of this section.

It is to be noted that the Origin-Destination Summary dates from 1936-1937; as of 1941 there was a 25+% increase in traffic through the Dillon station so in the summary which follows that increase will be properly noted.

DILLON-TWIN BRIDGES 28 Miles
DIVERTED TRAFFIC, 1960

Category and Type	Length Miles	1936-37	+ 25% 1941	Normal Growth + 30% 1960
Diversion Through To Boulder	28.0			
Passenger Cars, Local		29	36	47
Passenger Cars, Foreign		5	6	8
All Passenger Cars		34	42	55
Trucks, Light		3.2	4.0	5.2
Trucks, Medium		0.8	1.0	1.3
Trucks, Heavy		0.1	0.1	0.1
Trac. Tks. & Semi-Trlrs.		0.8	1.1	1.5
Trucks & Full Trailers		0.3	0.4	0.5
Busses		0.9	1.1	1.4
All Trucks and Busses		6.1	7.7	10.0
All Vehicles		40.1	49.7	65.0

DILLON-TWIN BRIDGES 28 Miles
DIVERTED TRAFFIC, 1960

Category and Type	Length Miles	1936-37	+ 25% 1941	Normal Growth + 30% 1960
Diversion Through To Whitehall	28.0			
Passenger Cars, Local		24	30	39
Passenger Cars, Foreign		10	13	17
All Passenger Cars		34	43	56
Trucks, Light		5.4	6.8	8.8
Trucks, Medium		1.4	1.7	2.2
Trucks, Heavy		0.1	0.2	0.2
Trac. Tks. & Semi-Trlrs.		1.5	1.9	2.5
Tks. & Full Trailers		0.5	0.7	0.9
Busses		1.4	1.8	2.4
All Trucks & Busses		10.3	13.1	17.0
All Vehicles		44.3	56.1	73.0
Diverted Traffic	28.0			
Passenger Cars, Local				86
Passenger Cars, Foreign				25
All Passenger Cars				111
Trucks, Light				14.0
Trucks, Medium				3.5
Trucks, Heavy				0.3
Trac. Tks. & Semi-Trlrs.				4.0
Tks. and Full Trailers				1.4
Busses				3.8
All Trucks and Busses				27.0
All Vehicles				138.0

c. The Derivation of Traffic Categories

On reference to the ORIGIN-DESTINATION SUMMARY it will be noted that trips of interest in these analyses may be readily listed in the following general categories:

1. DILLON-SHERIDAN

Sheridan-Dillon	9 trips
Sheridan-Idaho	9 trips
Nebraska-Sheridan	3 trips
Madison County-Virginia City	9 trips
	30 trips

2. DILLON-TWIN BRIDGES

Twin Bridges-Dillon	9 trips
Dillon-Twin Bridges	36 trips
Dillon-Whitehall	9 trips
	54 trips

3. DILLON-BEAVERHEAD

Dillon-Beaverhead	104 trips
Beaverhead-Dillon	75 trips
Beaverhead-Beaverhead	37 trips
	216 trips

4. DILLON-BEAVERHEAD-MADISON

Dillon-Madison	18 trips
Beaverhead-Madison	8 trips
Madison-Dillon	8 trips
Madison-Minnesota	9 trips
	43 trips

In the first two categories we are reasonably sure as to the origin-destination of the trips; however, in the fourth category, that which cites a Madison County origin-destination, we have no data to indicate that the trips originate or end near Twin Bridges or Sheridan. To be impartial in the matter then, we will distribute those trips of the fourth category equally to each of the first two categories, making a total of 51 Dillon-Sheridan trips and 76 Dillon-Twin Bridges trips. In terms of percentage the distribution would be 40% and 60% respectively.

Now let us refer to traffic records at hand for a station at the Point of Rocks as of 1941, which station represents the lowest point in traffic volume on the road between Dillon and Twin Bridges. We will find an average of 72 vehicles on the road leading to Dillon, 53 on the road leading to Twin Bridges, and 23 on the road leading easterly from the Point of Rocks. Let us say that the difference in traffic volume between the Dillon leg of the station and the Twin Bridges leg represents that Dillon-Sheridan traffic which leaves the Dillon-Twin Bridges road to proceed via existing county roads to Sheridan and nearby points. In this case, the volume of Dillon-Sheridan traffic would be 19 vehicles per day.

Next let us say that the volume of traffic on the Twin Bridges leg of the station represents the magnitude of traffic which travels the whole distance between Dillon and Twin Bridges, a part of which is Dillon-Sheridan traffic. As of 1960 the Dillon-Twin Bridges traffic in whole would be 102 vehicles per mile (53 x 1.50 x 1.30) and the Dillon-Sheridan Partial traffic would be 31 vehicles per day (19 x 1.25 x 1.30). See discussion Section III for application of factors in estimation of traffic volumes. The total of the Dillon-Twin Bridges and the Dillon-Sheridan traffic is thus found to be 133 vehicles per day of which 31 or 23% have been now allocated to the Dillon-Sheridan category. But, in the conclusions advanced in the Origin-Destination

studies, we had determined that Dillon-Sheridan traffic comprised 40% of the whole of the combined traffic between Dillon and the two Madison County towns. To work with round numbers, we will take 20% of the listed Dillon-Twin Bridges traffic as being representative of that Dillon-Sheridan traffic which travels through Twin Bridges, either going or returning on trips. This figure - 20.4 - plus 31 equals 51.4 or 39% of the whole, 133, to come reasonably close to the first 40-60 distribution.

That traffic which builds up between the Point of Rocks and Twin Bridges over and above the predetermined Dillon-Twin Bridges traffic is now labeled Point of Rocks-Twin Bridges traffic and is, of course, local in characteristics. That traffic over and above the predetermined Dillon-Twin Bridges and Dillon-Sheridan, Partial traffic between the Point of Rocks and Dillon will be known as Dillon-Beaverhead traffic.

3. Annual Revenues

To arrive at an estimate of annual revenues the traffic data were resolved into vehicle miles and then into ton miles. These data were extended on the basis of unit net revenues per ton mile to arrive at an estimate of the total annual income. Unit net revenue rates derive from a general study conducted by this department. Average gross ton figures for each class of vehicle were also ascertained in course of the research work of the Planning Survey.

HIGHWAY PROJECT ANALYSIS

1960 Traffic Income

Location of Project Montana Description of project Dillon-Twin Bridges County Beaverhead & Madison
Highway FA Route #49 Highway System Primary Length 28.0 miles Date of analysis January, 1946

Traffic Type	Average Annual Traffic				Average Annual Road Use During Life of Project-Ton Mi.	Unit Net Revenues Per Ton Mi. Dollars	Total Annual Net Revenue
	Existing Traffic		Diverted Traffic				
	Vehicles 1/	Ton 2/Miles	Vehicles	Ton Miles			
Passenger Cars - Mont.	62,495	2,624,797	31,390	1,318,380	3,943,177	0.002188	$ 8,628
Passenger Cars--Foreign	3,258	136,848	9,125	383,264	520,112	0.001799	936
Total Passenger Cars	65,753	2,761,645	40,515	1,701,644	4,463,289	0.00	$ 9,564
Trucks, Light	16,770	1,535,363	5,110	467,880	2,003,243	0.003248	$ 6,507
Trucks, Medium	1,166	224,782	1,278	246,204	470,986	0.002382	1,122
Trucks, Heavy	602	188,080	110	34,356	222,436	0.001619	360
Trucks, semi-trailer	1,094	451,852	1,461	603,792	1,055,644	0.001543	1,629
Trucks, full-trailer	762	488,170	511	327,516	815,686	0.001396	1,139
Busses, school							
Busses, other	1,131	285,105	1,387	349,524	634,629	0.001873	$ 1,189
Total Tks. & Busses	21,525	3,173,352	9,857	2,029,272	5,202,624		$11,946
Total all vehicles	87,278	5,934,997	50,372	3,730,916	9,665,913		$21,510

Average weight of trucks 5.92 tons; All vehicles 2.51 tons. Total Annual Income...$21,510

Percentage truck traffic 31,382/137,650 22.8%

Amortization period Twenty years and Forty years.

1/ Average daily traffic, each component, multiplied by 365, the number of days in the year.

2/ Vehicles multiplied by the average gross weights, each component of traffic, times the length of the project, 28.0 miles. Average gross weights are as follows:-

Passenger Cars..............................	1.50 tons
Trucks, Light...............................	3.27 tons
Trucks, Medium..............................	6.88 tons
Trucks, Heavy...............................	11.15 tons
Trac. Truck-semi Trailer Combinations.......	14.76 tons
Truck and full Trailer combinations.........	22.89 tons
Busses,.....................................	9.00 tons

4. Time Element Savings

Time element savings accrue to traffic as a result of surface and alignment improvements and because of shortened travel distance. In this particular case the Existing Traffic, all categories, will be enabled to travel at accelerated speeds due to surface and alignment improvements and decreased travel distance. That traffic diverted through to Boulder will save 17 miles of travel distance and the balance of the diverted traffic will save 40 miles. Composite time element savings are tabulated hereinafter. The "New" speed rates originate with studies conducted by the Oregon Highway Department and coincide with the speeds recommended by Standard No. 1. (See Basic Design Categories, pages i and ii). Present travelled way speed rates are set in accord with Oregon standards.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Beaverhead-Madison

Description of project Dillon - Twin Bridges

Highway number F.A. Route No. 49 Highway System F.A. Primary

Length 28.0 miles Date of analysis January 1946

	Dillon-Sheridan Partial		Dillon-Beaverhead	
	New	PTW 3/	New	PTW
Annual Traffic Volume				
Private Passenger cars (per year)	8395		31,390	
Trucks, light (per year).........	2190		5,293	
Trucks, medium (per year)........	219		365	
1/Trucks, heavy (per year).........	511		1,278	
Totals......................	11315		38,326	
Private Passenger Cars				
Average speed (miles per hour)...	43	36.5 2/	43	36.5
Distance (Miles).................	13.6	14.0	13.35	13.75
Time (hours per trip)............	0.316	0.384	0.310	0.377
Time savings per vehicle.........	0.068		0.067	
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume............	8395		31,390	
Totals......................	$ 343		$1,262	

Time Element Savings (Cont)

	Dillon-Sheridan Partion New	Dillon-Sheridan Partion PTW	Dillon-Beaverhead New	Dillon-Beaverhead PTW
Trucks, Light				
Average speed (miles per hour)..	39	33	39	33
Distance (miles)................	13.6	14.0	13.35	13.75
Time (hours per trip)...........	0.349	0.424	0.342	0.417
Time savings per vehicle........	0.075		0.075	
Value of savings ($/vehicle hour)	$0.86		$0.86	
Annual traffic volume...........	2,190		5,293	
Total...........................	$ 141		$ 341	
Trucks, Medium				
Average speed (miles per hour)..	35	29	35	29
Distance (miles)................	13.6	14.0	13.35	13.75
Time (hours per trip)...........	0.388	0.483	0.381	0.474
Time savings per vehicle........	0.095		0.093	
Value of savings($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume...........	219		365	
Total...........................	$ 24		$ 40	
Trucks, Heavy				
Average speed (miles per hour)..	32	26	32	26
Distance (miles)................	13.6	14.0	13.35	13.75
Time (hours per trip)...........	0.425	0.538	0.417	0.529
Time savings per vehicle........	0.113		0.112	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume...........	511		1,278	
Total...........................	$85		$210	
Total Each Category........	$ 593		$1853	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS			$2446	

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of Project Montana County Beaverhead-Madison

Description of project Dillon - Twin Bridges

Highway number F.A. Route No. 49 Highway System F.A. Primary

	Dillon - Twin Bridges New	Dillon - Twin Bridges PTW	Twin Bridges - Point of Rocks New	Twin Bridges - Point of Rocks PTW
Annual Traffic Volume				
Private Passenger Cars(per year).	27,375		37,595	
Trucks, light (per year).........	7,738		10,585	
Trucks, medium (per year)........	511		730	
Trucks, heavy (per year).........	1,605		2,190	
Totals...........................	37,229		51,100	
Private Passenger Cars				
Average speed (miles per hour)...	43	35.5 [4]	43	35
Distance (miles).................	28	28.5	14.4	14.5
Time (hours per trip)............	0.651	0.803	0.335	0.414
Time savings per vehicle.........	0.152		0.079	
[5] Value of savings($/vehicle-hour)	$0.60		$0.60	
Annual traffic volume............	27,375		37,595	
Total............................	$ 2,497		$ 1,782	

Time Element Savings (Cont)

	Dillon – Twin Bridges		Twin Bridges – Point of Rocks	
	New	PTW	New	PTW
Trucks, Light				
Average speed (miles per hour)	39	31.5	39	31
Distance (miles)	28	28.5	14.4	14.5
Time (hours per trip)	0.718	0.905	0.369	0.468
Time savings per vehicle	0.187		0.099	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume	7,738		10,585	
Total	$1,244		$901	
Trucks, Medium				
Average speed (miles per hour)	35	27.5	35	27
Distance (miles)	28	28.5	14.4	14.5
Time (hours per trip)	0.800	1.036	0.411	0.537
Time savings per vehicle	0.236		0.126	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume	511		730	
Total	$141		$108	
Trucks, Heavy				
Average speed (miles per hour)	32	24.5	32	24
Distance (miles)	28	28.5	14.4	14.5
Time (hours per trip)	0.875	1.163	0.450	0.604
Time savings per vehicle	0.288		0.154	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume	1,605		2,190	
Total	$ 679		$ 496	
Total Each Category	$4,561		$3,287	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS			$7,848	

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Beaverhead-Madison
Description of project Dillon-Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 28.0 miles Date of analysis January 1946

DIVERTED TRAFFIC

	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Annual Traffic Volume				
Private Passenger cars(per year)	20,075		20,440	
Trucks, light (per year)	1,898		3,212	
Trucks, medium (per year)	475		803	
Trucks, heavy (per year)	1,278		2,191	
Totals	23,726		26,646	
Private Passenger Cars				
Average speed (miles per hour)	43	43	43	43
Distance (miles)	84	101 7/	57	97 8/
Time (hours per trip)	1.953	2.349	1.326	2.256
Time savings per vehicle	0.396		0.930	

Time Element Savings (Cont)

DIVERTED TRAFFIC

	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Private Passenger Cars (Cont)				
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume...........	20,075		20,440	
Value of time savings...........	$4,770		$11,406	
6/Total at 40% & 66 2/3% resp.	$1,908		$ 7,604	
Trucks, Light				
Average speed (miles per hour)...	39	39	39	39
Distance (miles)................	84	101	57	97
Time (hours per trip)...........	2.154	2.590	1.462	2.487
Time savings per vehicle.........	0.436		1.025	
Value of savings($/vehicle-hour).	$0.86		$0.86	
Annual traffic volume...........	1,898		3,212	
Value of time savings...........	$712		$2,831	
Total at 40% & 66 2/3% resp.	$285		$1,887	
Trucks, Medium				
Average speed (miles per hour)...	35	35	35	35
Distance (miles)................	84	101	57	97
Time (hours per trip)...........	2.400	2.886	1.629	2.771
Time savings per vehicle.........	0.486		1.142	
Value of savings($/vehicle-hour).	$1.17		$1.17	
Annual traffic volume...........	475		803	
Value of time savings...........	$270		$1,073	
Total at 40% & 66 2/3% resp.	$108		$ 715	
Trucks, Heavy				
Average speed (miles per hour)...	32	32	32	32
Distance (miles)................	84	101	57	97
Time (hours per trip)...........	2.625	3.156	1.781	3.031
Time savings per vehicle.........	0.531		1.250	
Value of savings($/vehicle-hour).	$1.47		$1.47	
Annual traffic volume...........	1,278		2,191	
Value of time savings...........	$998		$4,026	
Total at 40% & 66 2/3% resp.	$399		$2,648	
Total Each Category.........	$2,700		$12,890	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS..................			$15,590	
TOTAL ANNUAL TIME ELEMENT SAVINGS......................			$25,884	

1/ Busses and trailer combinations included with heavy trucks.

2/ 6.5 miles at 38 m.p.h. plus 7.1 miles at 35 m.p.h. for 13.6 miles. Accordingly, PTW truck speeds, each classification, are set 6 miles less than the "New" rates.

3/ PTW - Present travelled way.

4/ 6.5 miles at 38 m.p.h. plus 22.0 miles at 35 m.p.h. will render a total average for 28 miles of 35.5 m.p.h. this being 7.5 m.p.h. less than the "New" rates for passenger cars. Accordingly, the PTW truck rates were set 7.5 m.p.h. less than the corresponding "New" rate.

5/ Value of Savings ($/vehicle-hour) from Technical Bulletin No. 7, Oregon State Highway Department.

6/ The element of possible diversion depends on completion of a through route from Dillon to Whitehall and Boulder via Twin Bridges. In the case of that traffic diverted through to Boulder a total of 69 miles of new roadway must be built - 28 miles, Dillon to Twin Bridges; 14 miles, north of Silver Star to Whitehall and 27 miles from Whitehall to Boulder. The mileage from Dillon to Twin Bridges comprises about 40% of the total required new construction, hence a 40% credit of total time element savings is assigned to the proposed project on completion thereof. With reference to the traffic which might be diverted through to Whitehall there is a total of 42 miles of new construction required to make the diversion effective - of which the Dillon-Twin Bridges section comprises 66 2/3%, hence credits are assigned in that amount.

7/ Distance from Dillon to Boulder via Butte, US-91.

8/ Distance from Dillon to Whitehall via Butte, US-91 and US-10.

5. Mileage Element Savings

These savings accrue to traffic as a circumstance of improved riding surface, decreased rise and fall, decreased gradient and improved alignment. These factors operate to decrease wear and tear on engines and tires; they make a gallon of gas stretch farther. The estimated savings are tabulated hereinafter. Procedures, based on methods in use by the Oregon State Highway Department are explained in notes set forth, thus 1/, 2/, etc.

HIGHWAY PROJECT ANALYSIS

1960 Mileage Element Savings

Location of project Montana County Beaverhead-Madison
Description of Project Dillon - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 28.0 miles Date of analysis January 1946

	Dillon-Sheridan Partial		Dillon-Beaverhead	
	New	PTW	New	PTW
Distance 1/, 2/				
Length (miles)...................	13.6	14.0	13.35	13.75
Distance saving (miles).........	0.40		0.4	
Average annual traffic (tons)...	28,886		85,971	
Annual traffic saving (ton-mi)..	11,554		34,388	
Cost ($/ton-mile)...............	$0.0191		$0.0196	
Total Saving................	$ 221		$ 674	
Surface 8/, 9/				
Roadway surface type............	483 - 0.03	0.24	483 - 0.03	0.24
Saving coefficient..............	0.21		0.21	
Aver. annual traffic (ton-mi.)..	392,849		1,147,713	
Saving ($/ton-mile) 0.019 x 0.21	$0.0040		$0.0041	
Total......................	$1,571		$4,706	

1960 Mileage Element Savings (cont)

	Dillon-Sheridan Partial		Dillon-Beaverhead	
	New	PTW	New	PTW
Rise and Fall 13/				
Rise and fall (feet)	No Change		No Change	
Saving (feet)				
Saving (foot-tons)				
Saving ($/foot-ton)				
Annual saving				
Total				
Gradient 17/				
Gradients in per cent	No Change		No Change	
Red'n in gradient				
Average An. traffic (ton-mi.)				
Saving ($/ton-mile)				
Total				
Alignment 21/, 22/				
Curvature rating	10	5	10	5
Points improvement	5		5	
Saving (point-ton-miles)	1,964,245		5,738,565	
Saving ($/point-ton-mile)	$0.0001		$0.0001	
Total	$196		$574	
Total Each Category	$1,988		$5,954	
SUB TOTAL ANNUAL MILEAGE SAVINGS			$7,942	

HIGHWAY PROJECT ANALYSIS

1960 Mileage Element Savings

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 28.0 miles Date of Analysis January 1946

	Dillon - Twin Bridges		Twin Bridges - Point of Rocks	
	New	PTW	New	PTW
Distance 3/,4/				
Length (miles)	28.0	28.5	14.4	14.5
Distance saving (miles)	0.5		0.1	
Average annual traffic (tons)	92,248.0		125,798	
Annual traffic saving (ton mi.)	46,124		12,580	
Cost ($/ton-mile)	$0.0191		$0.0191	
Total	$ 880		$ 240	
Surface 10/,11/				
Roadway surface type	483 - 0.03	0.26	483 - 0.03	0.28
Saving coefficient	0.23		0.25	
Aver. annual traffic (ton-mi.)	2,629,068		1,811,491	
Saving ($/ton-mile)	$0.0044		$0.0053	
Total	$11,569		$ 9,601	

1960 Mileage Element Savings (Cont)

	Dillon - Twin Bridges		Twin Bridges - Point of Rocks	
Rise and Fall 14/	New	FTW	New	FTW
Rise and Fall (feet)............	No	Change	No	Change
Saving (feet)...................				
Saving (foot-tons)..............				
Saving ($/foot-ton).............				
Total...........................				
Gradient 18/				
Gradients in per cent...........	No	Change	No	Change
Red'n in gradient...............				
Average An. traffic (ton-mi.)...				
Saving ($/ton mile).............				
Total...........................				
Alignment 23/, 24/				
Curvature rating................	10	2	10	0
Points improvement..............	8		10	
Saving (point-ton-miles)........	21,032,544		18,114,910	
Saving ($/point-ton-mile).......	$0.0001		$0.0001	
Total...........................	$ 2,103		$1,811	
Total Each Category........	$14,552		$11,652	
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.................			$26,204	

HIGHWAY PROJECT ANALYSIS

1960 Mileage Element Savings

Location of project Montana County Beaverhead - Madison

Description of Project Dillon - Twin Bridges

Highway number F.A. Route No. 49 Highway system F.A. Primary

Length 26.0 miles Date of Analysis January 1946

DIVERTED TRAFFIC

	Through to Boulder		Through to Whitehall	
	New	FTW	New	FTW
Distance 5/, 6/				
Length (miles)..................	84	101	57	97
Distance saving (miles).........	17		40	
Average annual traffic (tons)...	56,853		76,394	
Annual traffic saving (ton-mi.).	966,501		3,055,760	
Cost ($/ton-mile)...............	$0.0195		$0.0189	
Annual saving...................	$18,847		$57,754	
7/Total at 40% 7 66 2/3% resp.	$ 7,539		$38,503	
Surface 12/				
Roadway surface type............	No	Change	No	Change
Saving Coefficient..............				
Aver. annual traffic (ton.mi.)..				
Saving ($/ton-mile).............				
Total...........................				

	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Rise and Fall 15/,16/				
Rise and fall (feet)..........	3,220	5,150	1,020	5,810
Saving (feet)..................	1,930		4,790	
Saving (foot-tons)............	109,726,290		365,927,260	
Saving ($/foot-ton)...........	$4.21 x 10^{-6}		$4.45 x 10^{-6}	
Annual saving.................	$462		$1,628	
Total at 40% & 66 2/3% resp.	$185		$1,085	
Gradient 19/,20/				
Gradients in per cent.........	1.5	3.5	1.5	3.5
Red'n in Gradient.............	2.0		2.0	
Average An. traffic (ton-mi.).	4,775,652		4,354,458	
Saving ($/ton-mile)...........	$2.89 x 10^{-4}		$3.05 x 10^{-4}	
Annual saving..................	$1,380		$1,328	
Total at 40% & 66 2/3% resp.	$552		$ 885	
Alignment 25/				
Curvature rating...............	10	7	10	7
Points improvement............	3		3	
Saving (point-ton-miles)......	14,326,956		13,063,374	
Saving ($/point-ton-mile).....	$0.0001		$0.0001	
Annual saving..................	$1,433		$1,306	
Total at 40% & 66 2/3% resp.	$573		$871	
Annual Saving Each Category	$8,849		$41,344	
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS..............			$50,193	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.................			$84,339	

1/ Distance, DILLON-SHERIDAN, PARTIAL
Average Annual Traffic (tons)

Multiply the average daily traffic by 365 by the average gross weight for each component of traffic.

Annual Traffic Saving (ton-miles)

Multiply the average annual traffic in tons by the distance saving in miles.

Cost ($/ton-mile)

Find percentage of trucks thusly:

$$\frac{\text{No. of trucks}}{\text{All traffic}} = \frac{2,920}{11,315} = 25.8\%$$

Find average gross weight trucks thusly:

$$\frac{\text{Gross weight of trucks}}{\text{Number of trucks}} = \frac{16,293}{2,920} = \begin{matrix}\text{5.58 tons}\\ \text{11,160 pounds}\end{matrix}$$

From figure 113 of the Technical Bulletin we find that the truck mileage element operating cost for a truck of gross weight 11,160 pounds is $0.0143 per ton mile. Similar costs for passenger cars is $0.0207 per ton mile. Combining these costs in the proportion manifest in this particular category of traffic we have an operating cost of $0.0191 per ton mile.

See below:

Passenger Cars (74.2%) = 0.742 x \$0.0207 = \$0.0154
Truck Traffic (25.8%) = 0.258 x \$0.0143 = \$0.0037

Combined costs per ton mile = \$0.0191

Costs (\$/ton-mile) times the Annual Traffic Savings (ton-mile) equals the total saving.

2/ Distance, DILLON-BEAVERHEAD

$$\frac{\text{No. of trucks}}{\text{All Traffic}} = \frac{6{,}936}{38{,}326} = 18.1\% \text{ trucks}$$

$$\frac{\text{Gross Weight of Trucks}}{\text{Number of Trucks}} = \frac{38{,}886}{6{,}936} = \begin{array}{l} 5.606 \text{ tons} \\ 11{,}212 \text{ pounds average gross weight of trucks} \end{array}$$

Trucks

Operating cost, average gross weight of 11,212 pounds is \$0.0142 per ton mile. Combining costs in proportions manifest in this category we have a resultant \$0.0196 per ton mile.

Passenger Cars (81.9%) = 0.819 x \$0.0207 = \$0.0170
Truck Traffic (18.1%) = 0.181 x \$0.0142 = \$0.0026

Combined costs per ton mile = \$0.0196

3/ Distance, DILLON-TWIN BRIDGES

$$\frac{\text{No. of Trucks}}{\text{All Traffic}} = \frac{9{,}854}{37{,}229} = 26.5\% \text{ trucks}$$

$$\frac{\text{Gross Weight of Trucks}}{\text{Number of Trucks}} = \frac{51{,}186}{9{,}854} = \begin{array}{l} 5.194 \text{ tons} \\ 10{,}388 \text{ pounds, average gross weight of trucks} \end{array}$$

Operating costs, trucks, average gross weight of 10,388 pounds is \$0.0148 per ton mile. Combining costs in proportions manifest in this category of traffic we find a resultant of \$0.0191 per ton mile.

Passenger Cars, (73.5%) = 0.735 x \$0.0207 = \$0.0152
Truck Traffic (26.5%) = 0.265 x \$0.0148 = \$0.0039

Combined costs per ton mile = \$0.0191

4/ Distance, TWIN BRIDGES-POINT OF ROCKS

See Note 3/, the traffic being similar in weight and percentage characteristics.

5/ Distance, DIVERTED THROUGH TO BOULDER

$$\frac{\text{No. of Trucks}}{\text{All Traffic}} = \frac{3,651}{23,726} = 15.39\%$$

$$\frac{\text{Gross weight Trucks}}{\text{Number of Trucks}} = \frac{26,740}{3,651} = 7.324 \text{ tons} = 14,648 \text{ pounds, average gross weight trucks}$$

Truck operating costs, average gross weight 14,648 pounds is $0.0131 per ton mile. Combining costs in the proportions manifest in this category of traffic, we find the average to be 0.0195 per ton mile.

Passenger Cars (84.6%) = 0.846 x $0.0207 = $0.0175
Truck Traffic (15.4%) = 0.154 x $0.0131 = $0.0020

Combined cost per ton mile = $0.0195

6/ Distance, DIVERTED THROUGH TO WHITEHALL

$$\frac{\text{No. of Trucks}}{\text{All Traffic}} = \frac{6,206}{26,646} = 23.3\% \text{ Trucks}$$

$$\frac{\text{Gross weight of Trucks}}{\text{Number of Trucks}} = \frac{45,734}{6,206} = 7.369 \text{ tons} = 14,738 \text{ pounds}$$

Operating costs, trucks, average gross weight of 14,738 pounds is $0.0130 per ton mile. Combining costs in the proportions manifest in the category of traffic we find the average to be $0.0189 per ton mile.

Passenger Cars (76.7%) = 0.767 x $0.0207 = $0.0159
Truck Traffic (23.3%) = 0.233 x $0.0130 = $0.0030

Combined Cost per ton mile = $0.0189

7/ See Note 6/ Time Element Savings.

8/ Surface, DILLON-SHERIDAN, PARTIAL

It is proposed that high type bituminous surfacing, type 483, be placed on the project with a coefficient rating of 0.03. (See Technical Bulletin for discussion of coefficients). There is in place on this interval of the road, 6.5 miles of gravel surfacing, coefficient, 0.19, and 7.1 miles of unimproved surface, coefficient, 0.28. The combined coefficient rating is 0.24. This rating less the coefficient rating for the oil surfacing is 0.21 and this times the operating cost per ton mile gives the saving in dollars per ton mile. This figure times the average annual traffic in ton miles gives the annual monetary value of the surface savings.

9/ As above insofar as the degree of improvement is concerned.

10/ Surface - DILLON - TWIN BRIDGES

The present travelled way is gravel surfaced, coefficient rating 0.19, for a distance of 6.5 miles and unimproved, coefficient 0.28, for a distance of 22.0 miles. The combined coefficient rating would then be 0.26 and this less the coefficient rating of oil surface, 0.03, gives a saving coefficient of 0.23.

11/ Surface - TWIN BRIDGES - POINT OF ROCKS

The present travelled way bears a coefficient rating of 0.28 throughout - this less 0.03 gives us 0.25, the saving coefficient.

12/ Surface - DIVERTED TRAFFIC

The diverted traffic will not benefit by reason of surface savings - the roads from which this traffic will be diverted will be equal in surface value to that of the cut-off.

13/ and 14/ No significant change in reference to existing traffic.

15/ Rise and Fall, DIVERTED THROUGH TO BOULDER

Rise and Fall was computed on US-91 from Dillon to Boulder with elevation controls as follows:

DILLON - BOULDER VIA BUTTE

	Elev.	+	-
Dillon	5380		
			380
Navy Station	5000		
		630	
5 Mi. North Melrose.	5630		
			205
Moose Creek.	5425		
		205	
Moose Creek Hill	5630		
			230
Divide	5400		
		440	
Feeley (Cont. Divide).	5840		
			500
Nissler Jct.	5340		
		160	
Butte.	5500		
		900	
Woodville (Cont. Divide)	6400		
			1500
Boulder.	4900		
		2335	2815
		5150	

DILLON - BOULDER, VIA WHITEHALL

	Elev.	+	-
Dillon	5380		
			1020
Whitehall.	4360		
		1370	
Crest.	5730		
			830
Boulder.	4900		
		1370	1850
		3220	

It is assumed for purposes of this analysis that the improvement in rise and fall will be effective within the limits of the proposed improvement, the average gradient would then exist as 3.5. Truck fuel cost for 14,648 pound gross weight as shown on Figure 123 of the Technical Bulletin would be $6.87 x 10^{-6}. Passenger car costs on the same basis would be $3.72 x 10^{-6}. Combining the two traffic elements and extending we have an average saving of:

$$\begin{aligned} 15.4\% \text{ at } \$6.87 \times 10^{-6} &= 1.06 \times 10^{-6} \\ 84.6\% \text{ at } \$3.72 \times 10^{-6} &= \underline{3.15 \times 10^{-6}} \\ &\ \$4.21 \times 10^{-6} \end{aligned}$$

This saving times the Average Annual Traffic (tons) times the saving in feet in Rise and Fall gives the total monetary value of the annual savings in Rise and Fall.

16/ Rise and Fall, DIVERTED THROUGH TO WHITEHALL

Rise and Fall as it exists on US-91 and US-10 from Dillon to Whitehall via Butte was computed with elevation controls as follows:

DILLON - WHITEHALL VIA BUTTE

	Elev.	+	-
Dillon	5380		
			380
Navy Station	5000		
		630	
5 Mi. North Melrose.	5630		
			205
Moose Creek.	5425		
		205	
Moose Creek Hill	5630		
			230
Divide	5400		
		440	
Feeley (Cont. Divide).	5840		
			500
Nissler Jct.	5340		
		160	
Butte.	5500		

DILLON - WHITEHALL VIA BUTTE (Cont.)

	Elev.	+	-
		960	
Pipestone Pass (Cont. Divide). . . .	6460		
			2100
Whitehall.	4360		
		2395	3415
		5810	

DILLON - WHITEHALL

	Elev.	+	-
Dillon	5380		
			1020
Whitehall.	4360		

As for that traffic which was diverted through to Whitehall, the average gradient will exist within the limits of the project as 3.5. Truck fuel cost for average gross weight of 14,738 pounds as shown on Figure 123 of the Technical Bulletin would be $\$6.87 \times 10^{-6}$. Combining this cost with that for passenger cars in the proportions of traffic components common to this category we have costs as follows:-

$$\begin{array}{ll} 23.3\% \text{ at } \$6.87 \times 10^{-6} = & \$1.60 \times 10^{-6} \\ 76.7\% \text{ at } \$3.72 \times 10^{-6} = & \underline{\$2.85 \times 10^{-6}} \\ & \$4.45 \times 10^{-6} \end{array}$$

17/ and 18/ No significant change in reference to existing traffic.

19/ Gradient, DIVERTED THROUGH TO BOULDER

It is assumed that this traffic will be benefited by a 2% decrease in gradient by taking the Dillon-Twin Bridges-Whitehall-Boulder routing. By reference to the Technical Bulletin No. 7 and Figure 124 therein we find basic data as follows:

$$\begin{array}{ll} \text{Saving for passenger cars, } \$1.29 \times 10^{-4} \times 2.0 = & \$2.58 \times 10^{-4} \\ \text{Saving for trucks, gross weight, 14,648 pounds} = & \$6.25 \times 10^{-4} \\ & \underline{- \$1.67 \times 10^{-4}} \\ & = \$4.58 \times 10^{-4} \end{array}$$

Combining and extending in the proportions manifest in the category of traffic, we have:-

$$\begin{array}{ll} \text{Passenger Cars } (84.6\%) = 0.846 \times \$2.58 \times 10^{-4} = & \$2.18 \times 10^{-4} \\ \text{Truck Traffic } (15.4\%) = 0.154 \times \$4.58 \times 10^{-4} = & \underline{0.71 \times 10^{-4}} \\ \text{Combined Saving } = & \$2.89 \times 10^{-4} \end{array}$$

This figure times the Average Annual Traffic (ton-mile) is equal to the annual monetary value of the Gradient savings.

20/ Gradient, DIVERTED THROUGH TO WHITEHALL

Saving for passenger cars, $\$1.29 \times 10^{-4} \times 2 = \$2.58 \times 10^{-4}$
Saving for trucks, $\$6.25 \times 10^{-4} - \$1.67 \times 10^{-4} = \$4.58 \times 10^{-4}$

Combining these costs data in the relationship which each bears to the other we have:

Passenger Cars (76.7%) = $0.767 \times \$2.58 \times 10^{-4} = \$1.98 \times 10^{-4}$
Truck Traffic (23.3%) = $0.233 \times \$4.58 \times 10^{-4} = \$1.07 \times 10^{-4}$

Combined Value = $\$3.05 \times 10^{-4}$

21/ Alignment, DILLON - SHERIDAN, PARTIAL

It is not contemplated that improvement of this project will effect a great improvement in alignment as such; it is reasonable to think, however, that increased sight distances and a proper installation of super-elevation embodied in Standard No. 6 will make a significant alignment point improvement over this section. About half of this section has been improved with Federal Aid, hence the PTW curvature rating would be 5 assuming a curvature rating of 10 for the improved section and zero for the unimproved section. Subtracting this curvature rating from the "New" curvature gives us the relative point improvement, 5 in this case. This figure times the Average Annual Traffic (tons) times the length of the section under study times the Saving ($/point-ton-mile) will give the monetary value of the alignment savings. The latter mentioned multiplier derives from the Technical Bulletin.

22/ Alignment, DILLON-BEAVERHEAD

See note 21/ for determination of "Points improvement."

23/ Alignment, DILLON-TWIN BRIDGES

There are 6.5 miles of roadway improved to a curvature rating of 10 and 21.5 miles with zero point improvement. Combining and extending in the proportions detailed hereinabove we find a PTW curvature rating of 2. Subtracting this figure from the "New" curvature rating gives us the "Points improvement", 8 in this case.

24/ Alignment, TWIN BRIDGES - POINT OF ROCKS

None of this section has been improved to the standards set up in Standard No. 6; hence the curvature rating would be zero and the Points improvement would be 10.

25/ Alignment, DIVERTED TRAFFIC

Assume, in each case, the avoidance of city traffic in Butte with its inherent congestion and relief from mountainous curvature of Woodville Hill, Elk Park Canyon, Harding Way, Pipestone Pass will effect a 3 point improvement.

6. Traffic Benefits

This tabulation involves an allocation of benefits, non-fuel function and fuel function, in accord with the proportions advanced by the Oregon Highway Department, see the Technical Bulletin.

1960 Traffic Benefits

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 28.0 miles Date of analysis January 1946

Mileage Element Factors

Item			Fuel Function	Non-Fuel Function
Distance savings	$48,057	38%	$ 18,262	$ 29,795
Roadway surface savings	27,447	41%	11,253	16,194
Rise and fall savings	1,270	100%	1,270	
Gradient savings	1,437	100%	1,437	
Alignment savings	6,128	50%	3,064	3,064
Total Mileage Savings	$84,339		$35,286	$ 49,053

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	$ 15,396
Trucks, light	4,799
Trucks, medium	1,136
Trucks, heavy	4,553
Total Time Savings	$ 25,884

Recapitulation of Annual Benefits

Total Fuel Function Benefits $ 35,286

Non-fuel function (Mileage element factors $49,053
benefits (Time element factors 25,884

Total Non-Fuel Function Benefits $ 74,937

TOTAL ANNUAL BENEFITS $ 110,223

7. Derivation of Quotients

Now to marshal such factual data as we have assembled heretofore.

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 28.0 miles Date of analysis January 1946

I_{ar} = \$ 21,510 1/ K_1 = 1.00

C_a = \$ 47,676 2/ K_2 = 20,925/35,286 = 0.59

B_n = \$ 74,937 3/ K_3 = 0.05/0.20 = 0.25

B_f = \$ 35,286 K_2K_3 = 0.59 x 0.25 = 0.15

4/ K_1C_a = \$ 47,676 $1-K_2K_3$ = 1.00 - 0.15 = 0.85

5/ $Q_s = I_{ar}/K_1C_a$ = 21,510/47,676 = 0.45

6/ $Q_{Bn} = B_n/K_1C_a$ = 74,937/47,676 = 1.57

7/ $Q_{Bf} = B_f/K_1C_a$ = 35,286/47,676 = 0.74

8/ $Q'_s = Q_s - K_2K_3Q_{Bf}$ = 0.45 - 0.15 x 0.74 = 0.45 - 0.11 = 0.34

9/ $Q_c = 0.707\ (Q_s + Q_{Bn} + Q_{Bf}(1-K_2K_3))$ = 0.707 (0.45 + 1.57 + 0.74 x 0.85)
= 0.707 (0.45 + 1.57 + 0.63)
= 0.707 x 2.65 = 1.87

1/ The constant K_1 represents the Pro Rata cost chargeable to Road User funds, the Gasoline License tax in this case.

2/ The constant K_2 represents the proportion of the total fuel savings which derives from the diverted traffic. By reference to the tabulation of Mileage Element Savings we find that the fuel function benefits accruing to the diverted traffic are as follows:

Distance	0.38	x	\$46,042	=	\$17,496
Rise & Fall	1.00	x	1,270	=	1,270
Gradient	1.00	x	1,437	=	1,437
Alignment	0.50	x	1,444	=	722
Total Fuel Function Benefits				=	\$20,925

3/ The constant K_3 represents the ratio of fuel tax to the total cost of fuel. As a matter of interest, if we take the fuel savings accruing to the diverted traffic, \$20,925 and multiply by this factor, we get \$5,231, the net decrease in gas tax revenues for US-91 and US-10 in the area of the improvement. This to illustrate the necessity for the derivation of these constants in highway economics.

4/ By applying the constant K_1 to the annual capital costs we find the pro rata cost payable out of road user funds.

5/ Q_s represents the solvency quotient - if it were 1.00, annual revenues would balance estimated annual expenditures. In this case, the solvency quotient is 0.45, estimated revenues do not balance expenditures by an appreciable sum - at first glance we would say the routing is not feasible economically. But the highway picture involves a whole lot more than the mere comparison of income and expenditure. There are benefits which accrue to the road user which have an important bearing in the matter. These benefits, expressed as quotients hereinafter, when added to the solvency quotients express a "gross" financial solvency which in most instances will move most of the projects programmed into the "black".

6/ and 7/ Q_{Bn} and Q_{Bf} represent the benefit quotients, non-fuel and fuel. Note that these benefits, in this case, are 2.31 times the annual estimated capital costs.

8/ Q'_s is the corrected solvency quotient - the Dillon - Twin Bridges road, if built, and thus entered in the Montana Highway picture will act to decrease the revenues of those routes from which traffic is diverted. Q'_s represents the net solvency of the proposed improvement in respect to other parts of the highway system.

9/ Q_c represents the composite quotient. Heretofore we have determined financial solvencies, now we compare benefits with revenues to determine the feasibility or desirability of the route. In this particular instance the benefits are far in excess of revenues, to indicate that the road user not only accumulates funds (as represented by benefits) to pay his taxes but has a considerable "profit" left over. By virtue of the high composite solvency, 1,87, the road is eminently qualified to be built from Dillon to Twin Bridges as a Primary routing via the Point of Rocks and the west side of the Beaverhead River.

B. DILLON-POINT OF ROCKS, PRIMARY, 13.6 miles

Analysis "A" proves the over-all feasibility of building from Dillon to Twin Bridges via the Point of Rocks and the west side of the Beaverhead River, this as brought out in the discussion in Section I. Now to classify the several component sections proposed for analyses so that we can get at the core of the problem. It is to be noted that there is not much point to making an economic analysis of this particular section other than to establish its solvency rating and to extract the effect of such rating from the problem as a whole.

1. Annual Cost Calculations.

As brought out in Section IV, A, 1, it is assumed that this interval will be built to Standard No. 6 (See Basic Design Categories, pages i, ii). Work required would be re-shouldering, regravelling and oil surfacing of WPSO 344A-B, 6.5 miles and grading, installation of drainage structures, gravel base and surface construction and oil surfacing of 7.1 miles from the end of WPSO 344A-B to the Point of Rocks. Drawing on the experience data set forth in Section IV A, 1, we have estimated costs per mile as follows:-

Dillon through Projects WPSO 344A-B - 6.5 miles

See section IV A, 1,page 11, total estimated cost of new construction is $6,050 per mile.

From the end of WPSO 344A-B to the Point of Rocks, 7.1 miles.

See Section IV A, 1, page 14, total estimated cost of new construction, $17,710 per mile.

The total estimated cost of new construction would be:

6.5 x $ 6,050	=	$ 39,325
7.1 x $17,710	=	125,741
Total cost, 13.6 miles	=	$165,066

Add to this the 1936-1940 expenditures, $84,864 to bring the total cost of construction to $249,930. This sum when capitalized at 2½% to be amortized in 20 years gives us an annual capital construction cost of $16,020.

As brought out in the previous "Annual Cost Calculations", it is estimated that maintenance costs will aggregate $300 per mile per year to render the annual capital cost at $20,100, ($16,020 / 13.6 x $300). These data are summarized in somewhat lesser detail in the tabulation which follows:

ANNUAL COST CALCULATIONS

1960

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of analysis January 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	$ 9,556	2½%	20 years	$ 612
Clearing, grading, etc.	68,683	"	" "	4,403
Pavements and surfacing	90,990	"	" "	5,832
Structures:				
Type Minor	36,392	"	" "	2,333
Type Major	3,550	"	" "	228
1/ Other Construction items.....	40,759	"	" "	2,612
Unamortized cost old const...	249,930	"	" "	
1. Total annual capital cost..............................				$ 16,020

MAINTENANCE COSTS

	Gross 2/ Cost
2. Annual maintenance cost 13.6 miles at $300	$ 4,080
TOTAL ANNUAL COSTS (1 / 2)	$ 20,100

1/ Engineering, administration and / 10% for contingencies included with "Other Construction Items".

2/ To include administration and overhead.

2. Average Daily Traffic - 1960

A. Existing Traffic. Refer to Section IV, sub-section 2A.

Existing traffic over this section will comprise the following categories:

Dillon-Beaverhead, 13.35 miles at 105 vehicles per day.

Dillon-Sheridan, Partial, 13.6 miles at 31 vehicles per day.

Dillon-Sheridan, Through, 13.6 miles at 20.4 vehicles per day.

Dillon-Twin Bridges, 13.6 miles at 81.6 vehicles per day.

All existing traffic, 13.6 miles at 236 vehicles per day.

B. Diverted Traffic will travel over the whole of this section of the improvement. Average daily traffic, 138 vehicles.

C. All Traffic, 13.6 miles at 374 vehicles per day.

3. Annual Revenues.

Annual revenues will accrue by virtue of road use by each of the several traffic categories listed immediately herebefore. The tabulation of traffic income follows immediately hereinafter.

1/ Average daily traffic, each component, multiplied by 365, the number of days in the year.

2/ Vehicles multiplied by the average gross weights each component of traffic times the length of project, 13.6 miles.

4. Time Element Savings.

Refer to Section IV, Sub-section A4, for general discussion of these benefits. For this particular analysis, time element savings for the Dillon-Beaverhead traffic and the Dillon-Sheridan, Partial traffic will duplicate those shown on the first analysis and they will be so listed in the tabulations which follow this discussion. The Dillon-Twin Bridges category of traffic as set forth in the first analysis will be henceforth broken down into two categories of traffic; the Dillon-Sheridan, Through traffic and the Dillon-Twin Bridges traffic. Time element savings will be worked out in detail for the latter mentioned categories of traffic. Time element savings accruing to the diverted traffic will be allocated to the Dillon-Beaverhead section in the proportion in which the length, 13.6 miles, bears to the total "new" mileage, from Dillon to Twin Bridges, 28 miles.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Beaverhead - Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 13.6 miles Date of analysis January 1946

	Dillon-Beaverhead	Dillon-Sheridan Partial
Annual Traffic Volume		
Private Passenger cars (per year)	31,390	8,395
Trucks, light (per year).........	5,293	2,190
Trucks, medium (per year)........	365	219
1/ Trucks, heavy (per year).........	1,278	511
Totals..................	38,326	11,315
Private Passenger Cars		
Value of time savings............	$ 1,262	$ 343
Trucks, Light		
Value of time savings............	$ 341	$ 141
Trucks, Medium		
Value of time savings............	$ 40	$ 24
Trucks, Heavy		
Value of time savings............	$ 210	$ 85
Total Each Category.........	$ 1,853	$ 593
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS...............		$ 2,446

1/ Busses and trailer combinations included with trucks, heavy.

Time Element Savings

HIGHWAY PROJECT ANALYSIS

Location of Project Montana County Beaverhead-Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 13.6 miles Date of analysis January 1946

	Dillon-Sheridan Through		Dillon-Twin Bridges	
	New	PTW 2/	New	PTW
Annual Traffic Volume				
Private Passenger cars(per year)	5475		21900	
Trucks, light (per year)........	1548		6190	
Trucks, medium (per year).......	102		409	
Trucks, heavy (per year)........	321		1284	
Totals......................	7446		29783	
Private Passenger Cars				
Average speed (miles per hour)..	43	36.5	43	36.5
Distance (Miles)................	13.6	14.0	13.6	14.0
Time (hours per trip)...........	0.316	0.384	0.316	0.384
Time savings per vehicle........	0.068		0.068	
Value of savings($/vehicle-hour)	$0.60		$0.60	
Annual traffic volume...........	5475		21900	
Total.......................	$ 223		$ 894	
Trucks, Light				
Average speed (miles per hour)..	39	32.5	39	32.5
Distance (miles)................	13.6	14.0	13.6	14.0
Time (hours per trip)...........	0.349	0.431	0.349	0.431
Time savings per vehicle........	0.082		0.082	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume...........	1548		6190	
Total.......................	$ 109		$ 437	
Trucks, Medium				
Average speed (miles per hour)..	35	28.5	35	28.5
Distance (miles)................	13.6	14.0	13.6	14.0
Time (hours per trip)...........	0.388	0.491	0.388	0.491
Time savings per vehicle........	0.103		0.103	
Value of savings($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume...........	102		409	
Total.......................	$ 12		$ 49	
Trucks, Heavy				
Average speed (miles per hour)..	32	25.5	32	25.5
Distance (miles)................	13.6	14.0	13.6	14.0
Time (hours per trip)...........	0.425	0.549	0.425	0.549
Time savings per vehicle........	0.124		0.124	
Value of savings($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume...........	321		1284	
Total.......................	$ 59		$ 234	
Total Each Category.........	$ 403		$1614	

SUB TOTAL ANNUAL TIME ELEMENT SAVINGS $2017

2/PTW signifies present travelled way.

Time Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead - Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of analysis January 1946

	DIVERTED TRAFFIC	
	Through to Boulder	Through to Whitehall
Annual Traffic Volume		
Private Passenger cars (per year)	20,075	20,440
Trucks, light (per year).........	1,898	3,212
Trucks, medium (per year)........	475	803
Trucks, heavy (per year).........	1,278	2,191
Totals.....................	23,726	26,646
Private Passenger Cars		
Value of time savings...........	$927	$3,696
Trucks, Light		
Value of time savings...........	$139	$ 917
Trucks, Medium		
Value of time savings...........	$ 52	$ 347
Trucks, Heavy		
Value of time savings...........	$194	$1,304
Total Each Category...........	$1,312	$6,264

SUB TOTAL ANNUAL TIME ELEMENT SAVINGS .... $ 7,576
TOTAL ANNUAL TIME ELEMENT SAVINGS................ $ 12,039

5. Mileage Element Savings

Here as in the summary of the Time Element Savings, we are enabled to transfer the benefits for the Dillon-Beaverhead and the Dillon-Sheridan, Partial traffic directly from the first analysis. The mileage element benefits for the Dillon-Sheridan, Through and the Dillin-Twin Bridges traffic must, of necessity, be worked out in detail. Similar benefits for the diverted traffic will be allocated in the proportion that 13.6 miles bears to the total distance from Dillon to Twin Bridges, 28 miles.

Procedures in re computations are set forth in detail in Section IV, sub-section A,5.

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of analysis January 1946

	Dillon-Beaverhead	Dillon-Sheridan, Partial
Distance		
Annual saving....................	$ 674	$ 221

Mileage Element Savings (Cont)

	Dillon-Beaverhead	Dillon-Sheridan, Partial
Surface		
Annual Saving....................	$ 4,706	$ 1,571
Alignment		
Annual Saving....................	$ 574	$ 196
Total each category...........	$ 5,954	$ 1,988

SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS $ 7,942

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of Analysis January 1946

	Dillon-Sheridan Through		Dillon-Twin Bridges	
	New	PTW	New	PTW
Distance				
Length (Miles).................	13.6	14.0	13.6	14.0
Distance saving (miles)........	0.4		0.4	
Average annual traffic (tons)..	18,449		73,799	
Annual traffic saving (ton-mi.)	7,380		29,520	
Cost ($/ton-mile)..............	$0.0191		$0.0191	
Total......................	$ 141		$ 564	
Surface				
Roadway surfact type...........	483 - 0.03	0.24	483 - 0.03	0.24
Saving coefficient.............	0.21		0.21	
Aver. annual traffic (ton-mi.).	258,286		1,033,186	
Saving ($/ton-mile)............	$0.0191		$0.0040	
Total......................	$ 1,033		$ 4,133	
Alignment				
Curvature rating...............	10	5	10	5
Points improvement.............	5		5	
Saving (point-ton-miles).......	1,291,430		5,165,930	
Saving ($/point-ton-mile)......	$0.0001		$0.0001	
Total......................	$ 129		$ 517	
Total Each Category.........	$1,303		$5,214	

SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.............. $6,517

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon-Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of Analysis January 1946

	DIVERTED TRAFFIC	
	Through to Boulder	Through to Whitehall
Distance Annual Saving...................	$ 3,664	$18,712
Rise and Fall Annual Saving...................	$ 90	$ 527
Gradient Annual Saving...................	$ 268	$ 430
Alignment Annual Saving...................	$ 278	$ 423
Total Each Category..........	$ 4,300	$20,092
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...........		$24,392
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...............		$38,851

6. Traffic Benefits

Allocating benefits to fuel functions and non-fuel functions in accord with the procedures advanced by the Oregon Highway Department we have results as follows:

Traffic Benefits

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of analysis January 1946

Item	Mileage Element Factors		Fuel Function	Non-fuel Function
Distance savings	23,976	38%	$ 9,111	$ 14,865
Roadway surface savings	11,443	41%	4,692	6,751
Rise and Fall savings	617	100%	617	
Gradient savings	698	100%	698	
Alignment savings	2,117	50%	1,059	
Total Mileage savings	$38,851		$ 16,177	$ 22,674

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	$ 7,345
Trucks, light	2,084
Trucks, medium	524
Trucks, heavy	2,086
Total Time Savings	$ 12,039

Recapitulation of Annual Benefits

Total Fuel Function Benefits			$ 16,177
Non-fuel function benefits	(Mileage element factors	$22,674	
	(Time element factors	12,039	
Total Non-fuel Function Benefits			$ 34,713
TOTAL ANNUAL BENEFITS			$ 50,890

7. Derivation of Quotients

The measure of solvency of the Dillon-Point of Rocks road as proposed is shown herebelow:

Location of project Montana County Beaverhead-Madison
Description of project Dillon - Point of Rocks
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 13.6 miles Date of analysis December 1945

I_{ar} = $ 10,181 1/ K_1 = 1.00

C_a = $ 20,100 2/ K_2 = 10,169/16,177 = 0.63

B_n = $ 34,713 3/ K_3 = 0.05/0.20 = 0.25

B_f = $ 16,177 K_2K_3 = 0.63 x 0.25 = 0.16

4/ K_1C_a = $ 20,100 $1-K_2K_3$ = 1.00 - 0.16 = 0.84

5/ $Q_s=I_{ar}/K_1C_a$ = 10,181/20,100 = 0.505

6/ $Q_{Bn}=B_n/K_1C_a$ = 34,713/20,100 = 1.73

7/ $Q_{Bf}=B_f/K_1C_a$ = 16,177/20,100 = 0.805

8/ $Q'_s=Q_s-K_2K_3Q_{Bf}$ = 0.505 - 0.16 x 0.805 = 0.505 - 0.13 = 0.375

9/ $Q_c=0.707\ (Q_s+Q_{Bn}+Q_{Bf}\ (1-K_2K_3))$ = 0.707 (0.505 + 1.73 + 0.805 x 0.84)
= 0.707 (0.505 + 1.73 + 0.675)
= 0.707 x 2.91
= 2.06

1/ The constant K_1 represents the Pro Rata cost chargeable to Road Use Funds, the gasoline license tax levy in this case.

2/ The constant K_2 represents the proportion of the total fuel savings which derives from the diverted traffic. By reference to the tabulation of Mileage Element Savings we find that the fuel function benefits accruing to the diverted traffic are as follows:

Distance, 0.38 x 22,376 = $8,503
Rise and Fall, 1.00 x 617 = 617
Gradient, 1.00 x 698 = 698
Alignment, 0.50 x 701 = 351
Total Fuel Function Benefits =$10,169

3/ The constant K_3 represents the ratio of fuel tax to the total cost of fuel.

4/ By applying the constant K_1 to the annual capital cost we find the pro rata cost payable out of road user funds.

5/ through 9/ Note that all these quotients exceed those given in the first analysis. This comes about by reason of the fact that road building is more costly per mile from the Point of Rocks to Twin Bridges than it is from Dillon to the Point of Rocks. As in the first analysis this section of the Dillon-Twin Bridges routing is eminently qualified for construction as a primary routing as designated.

C. POINT OF ROCKS - TWIN BRIDGES, WEST OF RIVER, PRIMARY, 14.4 miles

By economic analyses we have proved the feasibility of construction of the Dillon-Twin Bridges road as a primary routing throughout its length, 28 miles, and from Dillon to the Point of Rocks, 13.6 miles as a primary routing. Now to determine the solvency rating of the Point of Rocks-Twin Bridges section if built to primary standards on the west side of the Beaverhead River.

1. Annual Cost Calculations

Utilizing such data as are afforded in the "experience" data set forth in this section, sub-section A,1, we have estimated construction costs as follows:

Grading, drainage, gravel base and surface construction, 14.4 miles at $20,020 per mile totalling $288,288.

Two major structures, one bridge at the Point of Rocks and one at Twin Bridges; $60,000 each totalling $120,000.

The total cost of new construction would be $408,288. On a capitalization basis, 2½% interest, the bridge costs to be retired in 40 years and the other costs to be amortized in 20 years we have an annual cost for construction of $23,255, (.0398 x $120,000 + .0641 x $288,288). Add to this the estimated annual maintenance cost, $4,320, (14.4 x $300), to arrive at an estimated annual capital cost of $27,575. These data are set forth in the tabulation which follows.

ANNUAL COST CALCULATIONS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 14.4 miles Date of analysis January 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	$ 21,600	2½%	20 yrs.	$ 1,385
Clearing, grading, etc.	$ 72,000	2½%	20 yrs.	4,615
Pavements and surfacing:	99,360	2½%	20 yrs.	6,369
Structures:				
Type Minor	43,200	2½%	20 yrs.	2,769
Type Major	120,000	2½%	40 yrs.	4,776
1/Other Construction items:.....	52,128	2½%	20 yrs.	3,341
Unamortized cost const........	408,288			
1. Total annual capital cost..............................				$ 23,255

MAINTENANCE COSTS

	Gross Cost 2/
2. Total annual maintenance cost 14.4 x $300	$ 4,320
TOTAL ANNUAL COSTS (1 ≠ 2)	$ 27,575

1/ Engineering, administration and ≠ 10% for contingencies included with "Other Construction Items."

2/ To include administration and overhead.

2. Average Daily Traffic, 1960

a. Existing traffic over this section will comprise the following categories:

Dillon-Sheridan, Through, 14.4 miles at 20.4 vehicles per day.
Dillon-Twin Bridges, 14.4 miles at 81.6 vehicles per day.
Point of Rocks-Twin Bridges, 14.4 miles at 140 vehicles per day.

b. Diverted traffic will travel the length of the section - average traffic, 138 vehicles per day.

c. All traffic, 14.4 miles at 380 vehicles per day.

3. Annual Revenues.

Annual revenues will accrue by virtue of road use by each of the several categories listed herebefore. The tabulation of traffic income follows immediately hereinafter.

HIGHWAY PROJECT ANALYSIS 1960 Traffic Income

Location of project Montana Description of project Point of Rocks-Twin Bridges County Madison
Highway F.A. Route #49 Highway System F.A. Primary Length 14.4 Mi. Date of analysis January 1946

Traffic Type	Average Annual Traffic				Average Annual Road Use During Life of Project-Ton.Mi	Unit Net Revenues Per Ton Mi Dollars	Total Annual Net Revenue
	Existing Traffic		Diverted Traffic				
	Vehicles	Ton Miles	Vehicles	Ton Miles			
Passenger Cars - Mont.	62,050	1,340,286	31,390	678,024	2,018,310	0.002188	$ 4,416
Passenger Cars - Foreign	2,920	63,072	9,125	197,107	260,179	0.001799	468
Total passenger cars	64,970	1,403,358	40,515	875,131	2,278,489		4,884
Trucks, light	18,323	862,794	5,110	240,624	1,103,418	0.003248	3,584
Trucks, medium	1,241	122,942	1,278	126,619	249,561	0.002382	595
Trucks, heavy	657	105,491	110	17,669	123,160	0.001619	199
Trucks, semi-trailer	1,203	255,692	1,461	310,522	566,214	0.001543	874
Trucks, full-trailer	694	228,756	511	168,437	397,193	0.001396	555
Busses, school							
Busses, other	1,241	160,833	1,387	179,755	340,588	0.001873	638
Total Tks. & Busses	23,359	1,736,508	9,857	1,043,626	2,780,134		$ 6,445
Total all vehicles	88,329	3,139,866	50,732	1,918,757	5,058,623		$11,329

Average weight of trucks 5.81 tons; All vehicles 2.53 tons. Total Annual Income $ 11,329

Percentage truck traffic 33,216/138,701 24%

Amortization period Twenty years and Forty years.

4. Time Element Savings

For this particular analysis the Point of Rocks - Twin Bridges benefits will be transferred in whole from the first analysis. The Dillon-Sheridan, Through benefits and the Dillon-Twin Bridges benefits will be itemized in detail. Time element savings for the diverted traffic will be allocated in the proportion that 14.4 miles bear to 28 miles - the 100% value of these savings are set forth in detail in the first analysis.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 14.4 miles Date of analysis January 1946

Annual Traffic Volume	Point of Rocks-Twin Bridges
Private Passenger cars (per year)...	37,595
Trucks, light (per year)............	10,585
Trucks, medium (per year)...........	730
Trucks, heavy (per year)............	2,190
Totals......................	51,100
Private Passenger Cars	
Value of time savings...............	$1,782
Trucks, Light	
Value of time savings...............	$ 901
Trucks, Medium	
Value of time savings...............	$ 108
Trucks, Heavy	
Value of time savings...............	$ 496
Total Each Category........	$3,287
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS....	$3,287

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 14.4 miles Date of Analysis January 1946

	Dillon-Sheridan Through		Dillon-Twin Bridges	
	New	PTW	New	PTW
Annual Traffic Volume				
Private Passenger Cars (per year)	5,475		21,900	
Trucks, light (per year).........	1,548		6,190	
Trucks, medium (per year)........	102		409	

	Dillon-Sheridan Through New	Dillon-Sheridan Through PTW	Dillon-Twin Bridges New	Dillon-Twin Bridges PTW
Annual Traffic Volume (Cont)				
Trucks, heavy (per year).........	321		1,284	
Totals...................	7,446		29,783	
Private Passenger Cars				
Average speed (miles per hour)...	43	35	43	35
Distance (Miles).................	14.4	14.5	14.4	14.5
Time (Hours per trip)............	0.335	0.414	0.335	0.414
Time savings per vehicle.........	0.079		0.079	
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume............	5,475		21,900	
Total....................	$ 260		$1,038	
Trucks, Light				
Average speed (miles per hour)...	39	31	39	31
Distance (miles).................	14.4	14.5	14.4	14.5
Time (hours per trip)............	0.369	0.468	0.369	0.468
Time savings per vehicle.........	0.099		0.099	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume............	1,548		6,190	
Total....................	$ 132		$ 527	
Trucks, Medium				
Average speed (miles per hour)...	35	27	35	27
Distance (miles).................	14.4	14.5	14.4	14.5
Time (hours per trip)............	0.411	0.537	0.411	0.537
Time savings per vehicle.........	0.126		0.126	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume............	102		409	
Total....................	$ 15		$ 60	
Trucks, Heavy				
Average speed (miles per hour)...	32	24	32	24
Distance (miles).................	14.4	14.5	14.4	14.5
Time (hours per trip)............	0.450	0.604	0.450	0.604
Time savings per vehicle.........	0.154		0.154	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume............	321		1,284	
Total....................	$ 73		$ 291	
Total Each Category......	$ 480		$1,916	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS			$2,396	1/

1/ These savings when added to those identical traffic category savings of analysis B are less by $148 than the Dillon-Twin Bridges savings listed in the first analysis, this because estimated speed rates, PTW, were computed to the nearest half mile.

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 14.4 miles Date of analysis January 1946

	DIVERTED TRAFFIC	
	Through to Boulder	Through to Whitehall
Annual Traffic Volume		
Private Passenger cars (per year).	20,075	20,440
Trucks, light (per year)..........	1,898	3,212
Trucks, Medium (per year).........	475	803
Trucks, heavy (per year)..........	1,278	2,191
Totals....................	23,726	26,646
Private Passenger Cars		
Value ot time savings.............	$ 981	$3,908
Trucks, Light.		
Value of time savings.............	$ 146	$ 970
Trucks, Medium		
Value of time savings.............	$ 56	$ 368
Trucks, Heavy		
Value of time savings.............	$ 205	$1,380
Total Each Category..........	$ 1,388	$6,626

SUB TOTAL ANNUAL TIME ELEMENT SAVINGS .... $ 8,014
TOTAL ANNUAL TIME ELEMENT SAVINGS.................. $13,697

5. Mileage Element Savings

Mileage element savings for the Point of Rocks-Twin Bridges traffic will be transferred in whole from those listed in the first analysis, Section IV, sub-section A,5. Those mileage element savings accruing to the Dillon-Sheridan, Through traffic and the Dillon-Twin Bridges traffic will be set forth in detail. For the diverted traffic, these benefits will be allocated from the first analysis in the proportion that 14.4 miles bears to 28.0 miles - in effect, the mileage element savings of this analysis plus those of the next preceding sub-section A, will equal the total of mileage element savings shown in the first analysis.

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project Montana County Madison
Description of Project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 14.4 miles Date of Analysis January 1946

	Point of Rocks - Twin Bridges
Distance	
Annual saving........................	$ 240
Surface	
Annual saving........................	$ 9,601
Alignment	
Annual saving........................	$ 1,811
Total each category..............	$ 11,652
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS	$ 11,652

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project Montana County Madison
Description of Project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 14.4 miles Date of Analysis January 1946

	Dillon-Sheridan Through		Dillon-Twin Bridges	
	New	PTW	New	PTW
Distance				
Length (miles)..................	14.4	14.5	14.4	14.5
Distance saving (miles).........	0.1		0.1	
Average annual traffic (tons)...	18,449		73,799	
Annual traffic saving (ton-mi.).	1,845		7,380	
Cost ($/ton-mile)...............	$0.0191		$0.0191	
Total.....................	$ 35		$ 141	
Surface				
Roadway surface type............	483 - 0.03	0.28	483 - 0.03	0.28
Saving coefficient..............	0.25		0.25	
Aver. annual traffic (ton.-mi.).	267,510		1,070,086	
Saving ($/ton-mile).............	$0.0048		$0.0048	
Total.....................	$1,284		$5,136	
Alignment				
Curvature rating................	10	0	10	0
Points improvement..............	10		10	
Saving (point-ton-miles)........	2,675,100		10,700,860	
Saving ($/point-ton-mile).......	$0.0001		$0.0001	
Total.....................	$268 1/		$1,070 2/	
Total Each Category........	$1,587		$6,347	
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.............			$7,934	

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project Montana County Madison
Description of Project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 14.4 miles Date of Analysis January 1946

	DIVERTED TRAFFIC	
	Through to Boulder	Through to Whitehall
Distance Annual savings..................	$ 3,875	$19,791
Rise and Fall Annual savings..................	$ 95	$ 558
Gradient Annual savings..................	$ 284	$ 455
Alignment Annual savings..................	$ 295	$ 448
Total Each Category...........	$ 4,549	$21,252
SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...........		$25,801
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS................		$45,387

1/ and 2/ In computing alignment point improvement in the first analysis we calculated on 8 point improvement in the first analysis for the Dillon-Twin Bridges traffic which included the Dillon-Sheridan, Through traffic and the Dillon-Twin Bridges traffic. In the second analysis, Dillon-Point of Rocks, we estimated an alignment point improvement of 5 points which was applied equally to both the latter mentioned categories. In this analysis we estimate a 10 point alignment improvement. In theory the sum of the mileage element savings in analysis B and C should equal the total of the mileage element benefits cited in the first analysis A; however, because of the fact that we extended to monetary values on the basis of whole numbers we have a differential in the combined results, this being $119. In the first analysis the total value of the alignment savings was computed to $2,103 - in the following two analyses the combined value was $1,984. The effect of such a small differential in the computation of solvency quotients is so little that we deem it more practical to work with whole numbers than to attempt to balance quantities by use of whole numbers and fractions.

6. Traffic Benefits.

Allocating benefits to fuel functions and non-fuel functions in accord with the procedures advanced by the Oregon Highway Department, we have results as follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 14.4 miles Date of analysis January 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	$24,082	38%	$ 9,151	$ 14,931
Roadway surface savings	16,021	41%	6,569	9,452
Rise and fall savings	653	100%	653	
Gradient savings	739	100%	739	
Alignment savings	3,892	50%	1,946	1,946
Total Mileage savings	$45,387		$ 19,058	$ 26,329

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	$ 7,969
Trucks, light	2,676
Trucks, medium	607
Trucks, heavy	2,445
Total Time Savings	$ 13,697

Recapitulation of Annual Benefits

Total Fuel Function Benefits		$ 19,058
Non-fuel function benefits	(Mileage element factors	$26,329
	(Time element factors	13,697
Total Non-fuel Function Benefits		$ 40,026
TOTAL ANNUAL BENEFITS		$ 59,084

7. Derivation of Quotients

The measure of solvency of the Point of Rocks-Twin Bridges road if built to primary standards on the west side of the Beaverhead River is as follows:

HIGHWAY PROJECT ANALYSIS

Location of Project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 14.4 miles Date of analysis January 1946

I_{ar} = $ 11,329 K_1 = 1.00
1/
C_a = $ 27,575 K_2 = 10,756/19,058 = 0.565
B_n = $ 40,026 K_3 = 0.05/0.20 = 0.25
B_f = $ 19,058 K_2K_3 = 0.565 x 0.25 = 0.14
K_1C_a = $ 27,575 $1-K_2K_3$ = 1.00 - 0.14 = 0.86

2/ $Q_s=I_{ar}/K_1C_a=$ 11,329/27,575 = 0.41

3/ $Q_{Bn}=B_n/K_1C_a=$ 40,026/27,575 = 1.45

4/ $Q_{Bf}=B_f/K_1C_a=$ 19,058/27,575 = 0.69

5/ $Q'_s=Q_s-K_2K_3Q_{Bf}$ = 0.41 - 0.14 x 0.69 = 0.41 - 0.10 = 0.31

6/ $Q_c=0.707\ (Q_s+Q_{Bn}+Q_{Bf}(1-K_2K_3))$ = 0.707 (0.41 + 1.45 + 0.69 x 0.86) =
= 0.707 (0.41 + 1.45 + 0.59)
= 0.707 x 2.45
= 1.73

1/ By reference to the tabulation of Mileage Element Savings we find that the fuel function benefits accruing to the diverted traffic are as follows:

Distance	0.38 x	$23,666 =	$8,993
Rise and Fall	1.00 x	653 =	653
Gradient	1.00 x	739 =	739
Alignment	0.50 x	371 =	371
Total Fuel Function Benefits......		=	$10,756

2/, 3/, and 4/ Note that these quotients are all lower than the counterpart quotients in the first two analyses, this because of increased construction costs on the west side of the river.

5/ Showing the net solvency in respect to other parts of the Federal-aid Primary System from which traffic is diverted.

6/ Showing that despite the increased construction costs this section is properly qualified by reason of the favorable comparison of benefits to revenues. Note also that basic data deriving from this analysis were used in the SUMMARY OF FINDINGS, Section I in the preparation of the Ratio Chart, page 3 of this report.

D. POINT OF ROCKS - TWIN BRIDGES, WEST OF RIVER, SECONDARY, 14.4 Miles

This will be an economic analysis of a road as per title above if built in combination with a road built to primary standards east of the river. Such a combination of constructions is represented by the heavy solid line of the ratio chart, page 3 of this report.

1. Annual Cost Calculations.

These data derive from the "experience" tabulation of construction costs set forth in the early phases of this section. It being contemplated that this road will be built to secondary standards there will be a significant drop in estimated construction costs per mile, although major bridge structures will remain the same as shown in the first analysis.

Grading....................................	$4,500
$500 less per mile than if built to primary standards.	
Minor Structures...........................	$3,000
Same as if built to primary standards.	
Gravel Base and Surfacing..................	$4,250
$250 less per mile than if built to primary standards.	
Oil Surfacing..............................	$2,000
$400 less per mile than if built to primary standards.	
Right-of-way...............................	$1,250
$250 less per mile than if built to primary standards.	
Engineering................................	$1,500
$200 less per mile than if built to primary standards.	
Administration.............................	$ 100
Same as if built to primary standards.	
Sub-total new construction costs per mile....	$16,600
/ 10% for contingencies....................	1,660
Total estimated cost per mile..............	$18,260

The over-all cost for new construction would be $262,944 (14.4 x $18,260). Add to this the cost of the two bridges to bring the total cost of construction to $382,944, (262,944 ≠ $120,000). Resolving these results to a capital cost level, 2½% interest, the bridge costs to be amortized in 40 years and the other construction costs to be retired in 20 years, we find the annual capital cost for construction to be as follows:

Bridge Construction Costs,	$120,000 x 0.0398 =	$ 4,776
Other Construction Costs,	262,944 x 0.0641 =	$16,855
	Annual Capital Costs =	$21,631

Assuming an annual maintenance cost of $150 per mile, the annual maintenance charge would be $2,160, (14.4 x $150).

The total annual capital cost as of 1960 would then be $23,791 ($21,631 ≠ $2,160).

These data are set forth in the tabulation which follows hereinafter:

ANNUAL COST CALCULATIONS

Location of project Montana County Madison
Description of project Point of Rocks, - Twin Bridges
Highway number FAS No. 282 Highway system F.A. Secondary
Length 14.4 miles Date of analysis January 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	$ 18,000	2½%	20 yrs.	$ 1,154
Clearing, grading, etc.	64,800	2½%	20 yrs.	4,154
Pavements and surfacing	90,000	2½%	20 yrs.	5,769
Structures:				
Type Minor	43,200	2½%	20 yrs.	2,769
Type Major	120,000	2½%	40 yrs.	4,776
1/ Other Construction items......	46,944	2½%	20 yrs.	3,009
Unamortized cost const.........	382,944			
1. Total annual capital cost....................................				$21,631

MAINTENANCE COSTS

	Gross Cost 2/
2. Total annual maintenance cost 14.4 miles at $150	$ 2,160
TOTAL ANNUAL COSTS (1 ≠ 2)	$23,791

1/ Engineering, administration, and ≠ 10% for contingencies included with "Other Construction Items".

2/ To include administration and overhead.

2. Average Daily Traffic, 1960

a. Existing traffic over this section will comprise the following categories:-

Dillon-Twin Bridges, 14.4 miles at 81.6 vehicles per day.
Point of Rocks-Twin Bridges, 14.4 miles at 140 vehicles per day.

b. Diverted Traffic -

Due to the fact that this section will be built to secondary standards and under the hypothesis, the road east of the river will be built to primary standards, it is presumed that only 30% of the diverted traffic will use the west side road if built, this despite the fact that the east side route will be one-half mile longer. Through traffic, the diverted traffic in this instance, prefers to use the primary marked system in preference to secondary routes. As time goes on the diverted traffic would learn to use the secondary routing to benefit by a decreased travel distance of one-half mile as cited herebefore. For purposes of this analysis, the 30% figure is deemed to be fair and just in the allocation of traffic values...the effective diverted traffic would then be 41.4 vehicles per day.

c. All traffic, 14.4 miles at 263 vehicles per day.

3. Annual Revenues.

Annual revenues will accrue by virtue of road use by each of the several categories listed herebefore. The tabulation of traffic income follows immediately hereinafter.

HIGHWAY PROJECT ANALYSIS 1960 Traffic Income

Location of project Montana
Description of project Point of Rocks-Twin Bridges
County Madison
Highway FAS No. 282
Highway system F.A. Secondary
Length 14.4 miles
Date of analysis January 1946

Traffic Type	Average Annual Traffic				Average Annual Road Use During Life of Project-Ton Mi Total	Unit Net Revenues Per Ton Mi Dollars	Total Annual Net Revenue
	Existing Traffic		Diverted Traffic				
	Vehicles	Ton Miles	Vehicles	Ton Miles			
Passenger cars - Montana	9,417	203,414	56,867	1,228,231	1,431,645		$ 3,133
Passenger cars - Foreign	2,738	59,127	2,628	56,759	115,886		208
Total passenger cars	12,155	262,541	59,495	1,284,990	1,547,531		$ 3,341
Trucks, light	1,533	72,185	16,775	789,830	862,015		2,799
Trucks, medium	383	37,987	1,139	112,830	150,817		360
Trucks, heavy	33	5,300	599	96,169	101,469		165
Trucks, semi-trailer	438	93,153	1,108	235,480	328,633		507
Trucks, full-trailer	154	50,530	628	206,980	257,510		359
Busses, school							
Busses, other	416	53,928	1,139	147,602	201,530		379
Total trucks & busses	2,957	313,083	21,388	1,588,891	1,901,974		$ 4,569
Total all vehicles	15,112	575,624	80,883	2,873,881	3,449,505		$ 7,910

Average weight of trucks 5.425 tons; All vehicles 2.50 tons. Total Annual Income $7,910

Percentage truck traffic 24,345/95,995 25.4%.

Amortization period Twenty years.

4. Time Element Savings

For purposes of this analysis we can extract the Time Element Savings for the existing traffic from the next preceding analysis. In regard to the diverted traffic, we can take 30% of the value set up for that traffic category in the next preceding analysis. The data are tabulated hereinbelow:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A.S. No. 282 Highway Sysgem F.A. Secondary
Length 14.4 miles Date of analysis January 1946

	Existing Traffic		Diverted Traffic @ 30%	
	Point of Rocks Twin Bridges	Dillon Twin Bridges	Through to Boulder	Through to Whitehall
Annual Traffic Volume				
Private Passenger cars (per year)	37,595	21,900	6,023	6,132
Trucks, light (Per year)........	10,585	6,190	569	964
Trucks, medium (Per year).......	730	409	143	241
Trucks, heavy (per year)........	2,190	1,284	383	657
Totals....................	51,100	29,783	7,118	7,994
Private Passenger Cars				
Value of time savings...........	$1,782	$1,038	$294	$1,172
Trucks, Light				
Value of time savings...........	$ 901	$ 527	$ 44	$ 291
Trucks, Medium				
Value of time savings...........	$ 108	$ 60	$ 16	$ 111
Trucks, Heavy				
Value of time savings...........	$ 496	$ 291	$ 62	$ 414
Total Each Category........	$3,287	$1,916	$416	$1,988

TOTAL ANNUAL TIME ELEMENT SAVINGS .... $ 7,607

5. Mileage Element Savings.

As for the Time Element Savings, these values for each of the several categories of traffic may be extracted from the next preceding analysis.

HIGHWAY PROJECT ANALYSIS

Mileage Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A.S. No. 282 Highway system F.A. Secondary
Length 14.4 miles Date of Analysis January 1946

	Existing Traffic		Diverted Traffic @ 30%	
	Point of Rocks Twin Bridges	Dillon Twin Bridges	Through to Boulder	Through to Whitehall
Distance Annual saving.....	$ 240	$ 141	$1,163	$5,937
Surface Annual saving.....	$ 9,601	$ 5,136	$	$
Rise & Fall Annual saving.....	$	$	$ 28	$ 168
Gradient Annual saving.....	$	$	$ 85	$ 137
Alignment Annual saving.....	$ 1,811	$ 1,070	$ 89	$ 134
Total Each Category	$11,652	$ 6,347	$1,365	$6,376

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.................$25,740

6. Traffic Benefits.

Allocating benefits to fuel functions and non-fuel functions, we have results as follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A.S. Route No. 282 Highway system F.A. Secondary
Length 14.4 miles Date of analysis January

	Mileage Element Factors		Fuel Function	Non-fuel Function
Item				
Distance savings	$7,481	38%	$ 2,843	$ 4,638
Roadway surface savings	14,737	41%	6,042	8,695
Rise and fall savings	196	100%	196	
Gradient Savings	222	100%	222	
Alignment savings	3,104	50%	1,552	1,552
Total Mileage savings	$ 25,740		$10,855	$14,885

Time Element Factors Traffic Benefits (Cont.)

Type of Traffic	Annual Value of Time Savings
Passenger cars	$ 4,286
Trucks, light	1,763
Trucks, medium	295
Trucks, heavy	1,263
Total Time Savings	$ 7,607

Recapitulation of Annual Benefits

Total Fuel Function Benefits		$10,855
Non-fuel Function benefits	(Mileage element factors $ 14,885 (Time Element factors 7,607	
Total Non-fuel Function Benefits		$22,492
TOTAL ANNUAL BENEFITS		33,347

7. Derivation of Quotients.

See tabulation which follows:

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges
Highway number F.A.S. Route No. 282 Highway system F.A. Secondary
Length 14.4 miles Date of analysis January 1946

$I_{ar} = \$\ 7,910$ $K_1 = 1.00$

$C_a = \$\ 23,791$ 1/ $K_2 = 3,228/10,855 = 0.295$

$B_n = \$\ 22,492$ $K_3 = 0.05/0.20 = 0.25$

$B_f = \$\ 10,855$ $K_2K_3 = 0.295 \times 0.25 = 0.075$

$K_1C_a = \$\ 23,791$ $1-K_2K_3 = 1.00 - 0.075 = 0.925$

2/ $Q_s = I_{ar}/K_1C_a = 7,910/23,791 = 0.33$

3/ $Q_{Bn} = B_n/K_1C_a = 22,492/23,791 = 0.945$

4/ $Q_{Bf} = B_f/K_1C_a = 10,855/23,791 = 0.455$

5/ $Q'_s = Q_s - K_2K_3Q_{Bf} = 0.33 - 0.075 \times 0.455 = 0.33 - 0.035 = 0.295$

6/ $Q_c = 0.707\ (Q_s + Q_{Bn} + Q_{Bf}(1-K_2K_3)) = 0.707\ (0.33 + 0.945 + 0.455 \times 0.925)$
$= 0.707\ (0.33 + 0.945 + 0.42)$
$= 0.707 \times 1.695$
$= 1.20$

1/ By reference to the tabulation of Mileage Element Savings we find fuel function benefits accruing to the diverted traffic as follows:

Distance, 0.38 x $7,100 = $2,698
Rise and Fall, 1.00 x 196 = 196
Gradient, 1.00 x 222 = 222
Alignment, 0.50 x 223 = 112
Total Fuel Function Savings = $3,228

2/, 3/, 4/, and 5/ Note that these quotients are the lowest obtained thus far in the report.

6/ The quotient is in excess of unity, hence, it is feasible from an economic standpoint to build the section as a secondary routing in combination with a primary routing east of the river. It will be remembered that this fact was so stated in Section I of this report, SUMMARY OF FINDINGS.

E. POINT OF ROCKS - TWIN BRIDGES, EAST OF RIVER, PRIMARY, 12.9 MILES NEW CONSTRUCTION

Now to weight the proposed construction cited hereabove from an economic standpoint. This proposal comprehends an auxiliary construction to secondary standards on the west side of the river. The ratio, benefits to expenditures, which is ascertained in this analysis, plus a similar ratio deriving from the next preceding analysis is shown as the basic vector (solid line) on the Ratio Chart in Section I, SUMMARY OF FINDINGS

1. Annual Cost Calculations.

This construction is favored by a terrain more adaptable to road building - there are fewer settlers along the route with a corresponding decrease in irrigation and drainage "hazards", so to speak. These conditions are reflected in a lower construction cost for this section than that proposed west of the river. Discussion in re estimated construction costs per mile follows hereinafter.

Grading.................................... $3,500

At a cost somewhat in excess of that experienced in the construction of FAP 281D,F which traversed similar terrain.

Minor Drainage Structures................. $3,000

At a cost somewhat in excess of that experienced in the construction of FAP 281C,F.

Gravel Base and Surface................... $4,500

At a cost somewhat in excess of that experienced in the construction of FAP 281C.

Oil Surface..............................	$2,400
At a cost similar to that experienced in the construction of FAP 281D,F.	
Right of Way..............................	$1,000
One-third less than that cost estimated for the road if built to primary standard west of the river by reason of less dense settlement.	
Engineering..............................	$1,700
As estimated for other sections covered in these analyses.	
Administration..............................	$ 100
As above.	
Sub Total....	$16,200
+ 10% for contingencies....	1,620
Sub-total, grading, drainage, etc.....	$17,820

This routing crosses the Ruby River to necessitate construction of a major structure at that point. There will be lesser bridge structures to erect in addition to that bridge over the Ruby River; however, it is estimated that $60,000 will cover the cost of bridge construction, this cost to include engineering, administration, etc.

The total estimated cost of new construction will be:

Grading, drainage, surfacing, 129 x $17,820	= $229,878
Bridges	= 60,000
Total Estimated Cost of New Construction	= $289,878

Applying interest at the rate of 2½%, the bridges to be retired in 40 years and the other items of construction to be amortized in 20 years, we have an annual construction capital cost of:

Bridges,	$60,000 x 0.0398	= $ 2,388
Other Items	$229,878 x 0.0641	= 14,735
Total Annual Capital Cost Construction		= $17,123

To this total we add maintenance costs at $300 per mile per year to render an annual capital cost at $20,993, ($17,123 + 3,870).

This data are set forth in somewhat lesser detail in the tabulation which follows.

ANNUAL COST CALCULATIONS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 12.9 miles Date of analysis January 1946

CAPITAL COSTS

Item	Net Cost	Interest Rate	Amort. Period	Annual Capital Cost
Rights of way, easements, etc.	$12,900	2½%	20 yrs.	$ 827
Clearing, grading, etc.	45,150	2½%	20 yrs.	2,894
Pavements and surfacing	89,010	2½%	20 yrs.	5,705
Structures:				
Type Minor	38,700	2½%	20 yrs.	2,481
Type Major	60,000	2½%	40 yrs.	2,388
1/Other Construction items......	44,118	2½%	20 yrs.	2,828
Unamortized cost const........	289,878			
1. Total annual capital cost..................................				$17,123

MAINTENANCE COSTS

	Gross Cost 2/
2. Total annual maintenance cost	$ 3,870
TOTAL ANNUAL COSTS (1 + 2)	$20,993

1/ Engineering, administration, and + 10% for contingencies included with "Other Construction Items".

2/ To include administration and overhead.

2. Average Daily Traffic, 1960

a. Existing traffic over this interval will comprise the following categories:

Dillon-Sheridan, Partial; 3.4 miles at 31 vehicles a day. It is assumed that this category of traffic will proceed from the Point of Rocks northeasterly 3.4 miles to a county road junction thence easterly via county roads to Sheridan, a distance of 11 miles. By so doing this traffic will save 5.6 miles, it being 9.5 miles from the county road junction with F.A. Route No. 29 and 7.1 miles from this junction to Sheridan via F.A. Route No. 29.

Dillon-Sheridan, Through; 12.9 miles at 20.4 vehicles per day. It is assumed that this element of traffic will stick to the improved road to thus benefit by reason of increased speeds and better riding surface.

Point of Rocks-Sheridan, 3.4 miles at 31 vehicles per day. This category of traffic represents the "pick-up" of local traffic enroute to Sheridan from the Point of Rocks easterly.

Point of Rocks-Twin Bridges, East; 12.9 miles, at 29 vehicles per day. This category of traffic represents the "pick-up" between the Point of Rocks and the junction of F.A. Routes No. 29 and 49, two miles south of Twin Bridges.

b. Diverted Traffic will comprise 70% of that total volume of diverted traffic shown in the first analysis, this per the hypothesis set forth in the next preceding analysis. The effective diversion will then be 96.6 vehicles per day for 12.9 miles.

c. All traffic, 12.9 miles at 162 vehicles per day.

3. Annual Revenues.

Annual revenues will develop as a circumstance of road use by each and all of the several traffic categories listed hereinbefore. The tabulation of traffic income is set forth as follows:

HIGHWAY PROJECT ANALYSIS 1960 Traffic Income

Location of project Montana Description of project Point of Rocks-Twin Bridges, East County Madison
Highway F.A. Route No. 49 Highway System F.A. Primary Length 12.9 miles Date of analysis February 1946

Traffic Type	Average Annual Traffic				Average Annual Road Use During Life of Project Total		Unit Net Revenues Per Ton Mi Dollars	Total Annual Net Revenue
	Existing Traffic		Diverted Traffic					
	Vehicles	Ton Miles	Vehicles	Ton Miles	Vehicles	Ton Mile		
Passenger Cars - Montana	16,350	316,390	21,973	425,171	38,323	741,561	0.002188	$1,622
Passenger Cars - Foreign	849	16,445	6,387	123,607	7,236	140,052	0.001799	251
Total passenger cars	17,199	332,835	28,360	548,778	45,559	881,613		$1,873
Trucks, light	5,403	227,927	3,577	150,892	8,980	378,819	0.003248	1,230
Trucks, medium	364	32,256	895	79,399	1,259	111,655	0.002382	266
Trucks, heavy	169	24,383	77	11,081	246	35,464	0.001619	58
Trucks, semi-trailer	319	60,540	1,023	194,726	1,342	255,266	0.001543	394
Trucks, full-trailer	215	63,774	357	105,625	572	169,399	0.001396	237
Busses, school								
Busses, other	326	37,729	971	112,720	1,297	150,449	0.001873	281
Total trucks and busses	6,796	446,609	6,900	654,443	13,696	1,101,052		$2,466
Total all vehicles	23,995	779,444	35,260	1,203,221	59,255	1,982,665		$4,339

Average weight of trucks 6.23 tons; All vehicles 2.59 tons. Total Annual Income..... $4,339

Percentage truck traffic 13,696/59,255 = 23%.

Amortization period Twenty years.

4. Time Element Savings

The Dillon-Sheridan, Partial traffic and the Point of Rocks-Sheridan traffic will benefit by reason of a decrease in travel distance of 0.1 miles and improvement of the riding surface to allow increased speeds. Point of Rocks-Twin Bridges traffic will benefit by reason of a decrease in travel distance of 0.6 miles and increased speed rates on completion of construction. The Dillon-Sheridan, Through traffic will benefit by reason of a 3.6 miles decrease in travel distance plus increased speeds allowed on completion of oil surfacing. Diverted traffic will benefit by reason of decreased travel distances, although in this particular case the distance between Dillon and Twin Bridges will be 0.5 miles in excess of that shown on the first analysis. Time Element Savings are tabulated as follows:

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway System F.A. Primary
Length 12.9 miles Date of analysis January 1946

	Dillon-Sheridan Partial		Dillon-Sheridan Through	
	New	PTW	New	PTW
Annual Traffic Volume				
Private Passenger cars (per year)	8,395		5,475	
Trucks, light (per year).........	2,190		1,548	
Trucks, medium (per year)........	219		102	
1/Trucks, heavy (per year).........	511		321	
Totals.....................	11,315		7,446	
Private Passenger Cars				2/
Average speed (miles per hour)...	43	35	43	36
Distance (miles)...............	3.4	3.5	12.9	16.5
Time (hours per trip)............	0.079	0.100	0.300	0.458
Time savings per vehicle.........	0.021		0.158	
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume...........	8,395		5,475	
Total......................	$ 106		$ 519	
Trucks, Light				
Average speed (miles per hour)...	39	31	39	32
Distance (miles)...............	3.4	3.5	12.9	16.5
Time (hours per trip)............	0.087	0.113	0.331	0.516
Time savings per vehicle.........	0.026		0.185	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume...........	2,190		1,548	
Total......................	$ 49		$246	
Trucks, Medium				
Average speed (miles per hour)...	35	27	35	28
Distance (miles)...............	3.4	3.5	12.9	16.5
Time (hours per trip)............	0.097	0.130	0.369	0.589
Time savings per vehicle.........	0.033		0.220	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume...........	219		120	
Total......................	$8		$26	

Time Element Savings (Cont)

	Dillon-Sheridan Partial		Dillon-Sheridan Through	
Trucks, Heavy	New	PTW	New	PTW
Average speed (miles per hour)...	32	24	32	25
Distance (miles)................	3.4	3.5	12.9	16.5
Time (hours per trip)...........	0.106	0.146	0.403	0.660
Time savings per vehicle.........	0.040		0.257	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume...........	511		321	
Total......................	$ 30		$ 121	
Total Each Category.........	$193		$ 912	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS................			$1105	

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison

Description of project Point of Rocks - Twin Bridges, East

Highway number F.A. Route No. 49 Highway System F.A. Primary

Length 12.9 miles Date of analysis January 1946

	Point of Rocks - Twin Bridges, East		Point of Rocks - Sheridan	
	New	PTW	New	PTW
Annual Traffic Volume				
Private Passenger cars (per hour)	7,300		8,395	
Trucks, light (per year).........	2,701		2,190	
Trucks, medium (per year)........	146		219	
Trucks, heavy (per year).........	438		511	
Totals.......................	10,585		11,315	
Private Passenger Cars		3/		
Average speed (miles per hour)...	43	35	43	35
Distance (miles)................	12.9	13.5	3.4	3.5
Time (hours per trip)...........	0.300	0.386	0.079	0.100
Time savings per vehicle.........	0.086		0.021	
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume...........	7,300		8,395	
Total.....................	$ 377		$ 106	
Trucks, Light				
Average speed (miles per hour)...	39	31	39	31
Distance (miles)................	12.9	13.5	3.4	3.5
Time (hours per trip)...........	0.331	0.435	0.087	0.113
Time savings per vehicle.........	0.104		0.026	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume...........	2,701		2,190	
Total.....................	$ 242		$ 49	
Trucks, Medium				
Average speed (miles per hour)...	35	27	35	27
Distance (miles)................	12.9	13.5	3.4	3.5
Time (hours per trip)...........	0.369	0.500	0.097	0.130
Time savings per vehicle.........	0.131		0.033	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume...........	146		219	
Total.....................	$ 18		$ 8	

Time Element Savings (Cont)

	Point of Rocks - Twin Bridges, East		Point of Rocks - Sheridan	
	New	PTW	New	PTW
Trucks, Heavy				
Average speed (miles per hour)..	32	24	32	24
Distance (miles)................	12.9	13.5	3.4	3.5
Time (hours per trip)...........	0.403	0.563	0.106	0.146
Time savings per vehicle........	0.160		0.040	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume...........	438		511	
Total...........................	$ 103		$ 30	
Total Each Category.............	$ 740		$193	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS...............			$933	

HIGHWAY PROJECT ANALYSIS

Time Element Savings

Location of project Montana County Madison

Description of project Point of Rocks - Twin Bridges, East

Highway number F.A. Route No. 49 Highway System F.A. Primary

Length 12.9 miles Date of analysis January 1946

DIVERTED TRAFFIC

	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Annual Traffic Volume				
Private Passenger cars (per year)	14,052		14,308	
Trucks, light (per year).........	1,328		2,249	
Trucks, medium (per year)........	333		562	
Trucks, heavy (per year).........	895		1,533	
Totals...........................	16,608		18,652	
Private Passenger Cars				
Average speed (miles per hour)...	43	43	43	43
Distance (miles).................	84.5	101	57.5	97
Time (hours per trip)............	1.965	2.349	1.337	2.256
Time savings per vehicle.........	0.384		0.919	
Value of savings($/vehicle-hour).	$0.60		$0.60	
Annual traffic volume............	14,052		14,308	
Value of time savings............	$3,238		$7,889	
4/Total at 19.47% & 32.45% resp.	$ 630		$2,560	
Trucks, Light				
Average speed (miles per hour)...	39	39	39	39
Distance (miles).................	84.5	101	57.5	97
Time (hours per trip)............	2.167	2.590	1.474	2.487
Time savings per vehicle.........	0.423		1.013	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume............	1,328		2,249	
Value of time savings............	$ 483		$1,959	
Total at 19.47% & 32,45% resp.	$ 94		$ 636	

Time Element Savings (Cont.)

	DIVERTED TRAFFIC			
	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Trucks, Medium				
Average speed (miles per hour)..	35	35	35	35
Distance (miles).................	84.5	101	57.5	97
Time (hours per trip)............	2.414		1.643	
Time savings per vehicle.........	0.472		1.128	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume............	333		562	
Value of time savings............	$ 184		$742	
Total at 19.47% & 32.45% resp	$ 36		$241	
Trucks, Heavy				
Average speed (miles per hour)..	32	32	32	32
Distance (miles).................	84.5	101	57.5	97
Time (hours per trip)............	2.641	3.156	1.797	3.031
Time savings per vehicle.........	0.515		1.234	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume............	895		1,533	
Value of time savings............	$678		$2,781	
Total at 19.47% & 32.45% resp	$132		$ 903	
Total Each Category..........	$892		$4,340	
SUB TOTAL ANNUAL TIME ELEMENT SAVINGS.............		$5,232		
TOTAL ANNUAL TIME ELEMENT SAVINGS..................		$7,270		

1/ Busses and trailer combinations included with Trucks, Heavy.

2/ It is assumed that the Dillon-Sheridan, Through traffic will have travelled over the west side road prior to improvement of this section. The average speed rate, PTW would be determined by combining distances and rates as follows:

2.0 miles at 43 mph = 86
14.5 miles at 35 mph = 507.5
16.5 miles at 36 mph = 593.5 very nearly

The difference between the "New" speed rates and the "PTW" speed rates in this case is 7 miles per hour; hence this figure was subtracted from the "New" speed rates of the other traffic components to arrive at "PTW" speed rates for the several types of vehicles.

3/ These speed rates ("PTW") derive from the Technical Bulletin and are identified generally with unimproved roads.

4/ As brought out in the early part of this report we have allocated benefits to traffic diverted through to Boulder and that diverted through to Whitehall on the basis of 40% and 66 2/3% of the whole, respectively; this in recognition of the fact that other projects involved in the construction of a through route from Dillon to Boulder are entitled to credit in the apportionment of benefits. In the allocation of benefits for fractional components of the Dillon-Twin Bridges construction we would break down the savings in the

proportion that the distance of the route being analyzed bears to the whole distance being constructed, in this case 26.5 miles. The factor would be 0.4868 - (12.9/26.5) and it would be applied to 40% and 66 2/3% to arrive at a benefit distribution factor of 0.1947 for that traffic diverted through to Boulder and 0.3245 for that traffic diverted through to Whitehall.

5. Mileage Element Savings

Mileage element savings are listed in detail as follows. Note that allocation of benefits to diverted traffic is made in the same manner as in the preparation of the tabulation of time element savings.

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 12.9 miles Date of analysis January 1946

	Dillon-Sheridan Partial		Dillon-Sheridan Through	
	New	PTW	New	PTW
Distance				
Length (miles)...............	3.4	3.5	12.9	16.5
Distance savings (miles)......	0.1		3.6	
Average annual traffic (tons).	28,886		18,449	
Annual traffic saving (ton-mi.)	2,889		66,416	
Cost ($/ton-mile)............	$0.0191		$0.0191	
Total....................	$ 55		$1,269	
Surface				
Roadway surface type..........	483 - 0.03	0.28	483 - 0.03	0.25
Saving coefficient............	0.25		0.22	
Aver. annual traffic (ton-mi.)	101,101		304,409	
Saving ($/ton-mile)...........	$0.0048		$0.0042	
Total....................	$ 485		$1,279	
Alignment				
Curvature rating..............	10	0	10	1
Points improvement............	10		9	
Saving (point-ton-miles)......	1,011,010		2,739,681	
Saving ($/point-ton-mile).....	$0.0001		$0.0001	
Total....................	$101		$274	
Total Each Category......	$641		$2,822	

SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.......... $ 3,463

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 12.9 miles Date of analysis January 1946

	Point of Rocks - Twin Bridges, East		Point of Rocks Sheridan	
	New	PTW	New	PTW
Distance				
Length (miles)..................	12.9	13.5	3.4	3.5
Distance saving (miles)........	0.6		0.1	
Average annual traffic (tons)..	26,740		28,886	
Annual traffic saving (ton-mi.)	16,044		2,889	
Cost ($/ton-mile)..............	$0.0191		$0.0191	
Total....................	$306		$55	
Surface				
Roadway surface type...........	483 - 0.03	0.28	483 - 0.03	0.28
Saving coefficient.............	0.25		0.25	
Aver. annual traffic (ton-mi)..	360,990		101,101	
Saving ($/ton-mile)............	$0.0048		$0.0048	
Total....................	$1,733		$485	
Alignment				
Curvature rating...............	10	0	10	0
Points improvement.............	10		10	
Saving (point-ton-miles).......	3,609.900		1,011,010	
Saving ($/point-ton-mile)......	$0.0001		$0.0001	
Total....................	$361		$101	
Total Each Category......	$2,400		$641	

SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...........$3,041

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 12.9 miles Date of analysis January 1946

DIVERTED TRAFFIC

	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Distance				
Length (miles)..................	84.5	101	57.5	97
Distance saving (miles)........	16.5		39.5	
Average annual traffic (tons)..	39,797		53,476	
Annual traffic saving (ton-mi.).	656,651		2,112,302	
Cost ($/ton-mile)..............	$0.0195		$0.0189	
Annual saving..................	$12,805		$39,923	
Total....................	$ 2,493		$12,956	

Mileage Element Savings (Cont)

HIGHWAY PROJECT ANALYSIS

	DIVERTED TRAFFIC			
	Through to Boulder		Through to Whitehall	
	New	PTW	New	PTW
Rise and Fall				
Rise and fall (feet)	3,220	5,150	1,020	5,810
Saving (feet)	1,930		4,790	
Saving (foot-tons)	76,808,210		256,150,040	
Saving ($/foot-ton)	$\$4.21 \times 10^{-6}$		$\$4.45 \times 10^{-6}$	
Annual saving	$323		$1.140	
Total	$ 63		$370	
Gradient				
Gradients in per cent	1.5	3.5	1.5	3.5
Red'n in gradient	2.0		2.0	
Average An. traffic (ton-Mi.)	4,019,497		5,187,172	
Saving ($/ton-mile)	$\$2.89 \times 10^{-4}$		$\$3.05 \times 10^{-4}$	
Annual saving	$1,162		$1,582	
Total	$226		$513	
Alignment				
Curvature rating	10	7	10	7
Points improvement	3		3	
Saving (point-ton-miles)	12,058,491		15,561,516	
Saving ($/point-ton-mile)	$0.0001		$0.0001	
Annual saving	$1,206		$1,556	
Total	$235		$ 505	
Total Each Category	$3,017		$14,344	

SUB TOTAL ANNUAL MILEAGE ELEMENT SAVINGS...... $ 17,361

TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.......... $ 23,865

6. Traffic Benefits

Allocating benefits to fuel functions and non-fuel functions in accord with procedures advanced by the Oregon Highway Department, we have results as follows:

HIGHWAY PROJECT ANALYSIS

Traffic Benefits

Location of project Montana County Madison

Description of project Point of Rocks - Twin Bridges, East

Highway number F.A. Route No. 49 Highway system F.A. Primary

Length 12.9 miles Date of analysis January 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	$17,134	38%	$6,511	$10,623
Roadway surface savings	3,982	41%	1,633	2,349
Rise and fall savings	433	100%	433	
Gradient savings	739	100%	739	
Alignment savings	1,577	50%	788	789
Total Mileage Savings	$23,865		$10,104	$13,761

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	\$ 4,298
Trucks, light	\$ 1,316
Trucks, medium	\$ 337
Trucks, heavy	\$ 1,319
Total Time Savings	\$ 7,270

Recapitulation of Annual Benefits

Total Fuel Function Benefits		\$10,104
Non-fuel function benefits	(Mileage element factors \$ 13,761	
	(Time element factors \$ 7,270	
Total Non-fuel Function Benefits		\$21,031
TOTAL ANNUAL BENEFITS		\$31,135

7. Derivation of Quotients

Having such factual data as are available in the preceding tabulations we are now prepared to determine the solvency rating of the section under analysis.

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Point of Rocks - Twin Bridges, East
Highway number F.A. Route No. 49 Highway system F.A. Primary
Length 12.9 miles Date of analysis January 1946

I_{ar} = \$ 4,339 K_1 = 1.00
1/
C_a = \$ 20,993 K_2 = 7,415/10,104 = 0.735
B_n = \$ 21,031 K_3 = 0.05/0.20 = 0.25
B_f = \$ 10,104 K_2K_3 = 0.25 x 0.735 = 0.185
K_1C_a = \$ 20,993 $1-K_2K_3$ = 1.00 - 0.185 = 0.815

2/ $Q_s = I_{ar}/K_1C_a$ = 4,339/20,993 = 0.205

3/ $Q_{Bn} = B_n/K_1C_a$ = 21,031/20,993 = 1.00

4/ $Q_{Bf} = B_f/K_1C_a$ = 10,104/20,993 = 0.48

5/ $Q'_s = Q_s - K_2 K_3 Q_{Bf} = \underline{0.205 - 0.185 \times 0.48 = 0.205 - 0.09 = 0.115}$

6/ $$\begin{aligned} Q_c = 0.707\,(Q_s + Q_{Bn} + Q_{Bf}(1 - K_2K_3)) &= \underline{7.07\,(0.205 + 1.00 + 0.48 \times 0.815)} \\ &= \underline{7.07\,(0.205 + 1.00 + 0.39)} \\ &= \underline{7.07 \times 1.595} \\ &= \underline{1.13} \end{aligned}$$

1/ By reference to the tabulation of mileage element savings we find fuel function benefits accruing to the diverted traffic as follows:

Distance	0.38 x 15,449	=	$5,871
Rise and Fall	1.00 x 433	=	433
Gradient	1.00 x 739	=	739
Alignment	0.50 x 740	=	370
	Total Function Savings	=	$7,413

Note further, in reference to this factor, that the diverted traffic forms the bulk of traffic over this routing with the effect of decreasing revenues on US-10 and US-91.

2/ It is to be noted that the solvency rating, 0.205, is less than the solvency rating, 0.33, shown in the next preceding analysis.

3/ Here the non-fuel benefit quotient exceeds that shown for the "west side" construction - this because of the fact that the diverted traffic forms the bulk of the traffic with corresponding high non-fuel benefits gained principally in distance saved.

4/ This quotient is somewhat in excess of that shown in the next preceding analysis principally because of the magnitude of fuel savings which accrue to diverted traffic.

5/ Note the effect of taking out the fuel function savings which benefit the diverted traffic.

6/ The project is feasible when built in combination with a secondary routing west of the river. Note, however, that the composite solvency quotient, 1.13, is 0.07 less than the composite solvency quotient of a secondary routing west of the river. As brought out in Section I, SUMMARY OF FINDINGS it is undoubtedly the better practice from an economic standpoint to build one route and one route only, and that west of the Beaverhead River.

F. COMBINED ROUTES, POINT OF ROCKS-TWIN BRIDGES, 27.3 miles.

As a point of interest we will now combine the several factors involved in the preparation of analyses D and E to arrive at an over-all solvency quotient for the combined routes, secondary west of the river and primary east of the river.

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Madison
Description of project Combined Routes Point of Rocks - Twin Bridges
Highway number F.A. Route No. 49 / F.A.S. Route No. 282 Highway system F.A. Primary / F.A.S. Secondary
Length 12.9 Primary - 14.4 Secondary Date of analysis January 1946

	I_{ar} = \$ 12,249	K_1	= 1.00
1/	C_a = \$ 44,784	K_2	= 10,641/20,959 = 0.51
2/	B_n = \$ 43,523	K_3	= 0.05/0.25 = 0.25
3/	B_f = \$ 20,959	K_2K_3	= 0.51 x 0.25 = 0.13
	K_1C_a = \$ 44,784	$1-K_2K_3$	= 1.00 - 0.13 = 0.87

$Q_s = I_{ar}/K_1C_a$ = 12,249/44,784 = 0.275

$Q_{Bn} = B_n/K_1C_a$ = 43,523/44,784 = 0.97

$Q_{Bf} = B_f/K_1C_a$ = 20,959/44,784 = 0.47

$Q'_s = Q_s - K_2K_3Q_{Bf}$ = 0.275 - 0.13 x 0.47 = 0.275 - 0.06 = 0.215

4/ $Q_c = 0.707\ (Q_s + Q_{Bn} + Q_{Bf}(1-K_2K_3))$ = 0.707 (0.275 + 0.97 + 0.47 x 0.87)
= 0.707 (0.275 + 0.97 + 0.41)
= 0.707 x 1.655
= 1.17

1/, 2/, 3/ These totals form the basic data in the preparation of the Ratio Charts, page 3 of this report.

4/ Note that this quotient strikes an average between those quotients determined in analyses D and E.

V. RECOMMENDATIONS

In accord with the information brought to light in the preceding analyses, it is recommended that the official description of Federal-aid Route No. 49 be so modified as to allow Federal-aid Primary construction west of the Beaverhead River between the Point of Rocks and Twin Bridges in Madison County.

Prepared and submitted by:

The Montana Highway Planning Survey

January 1946